REPORT OF AN IAEA SYMPOSIUM, VIENNA, NOVEMBER 1974

The Symposium was attended by 108 participants
and 15 observers representing 23 countries and 3 international organizations.

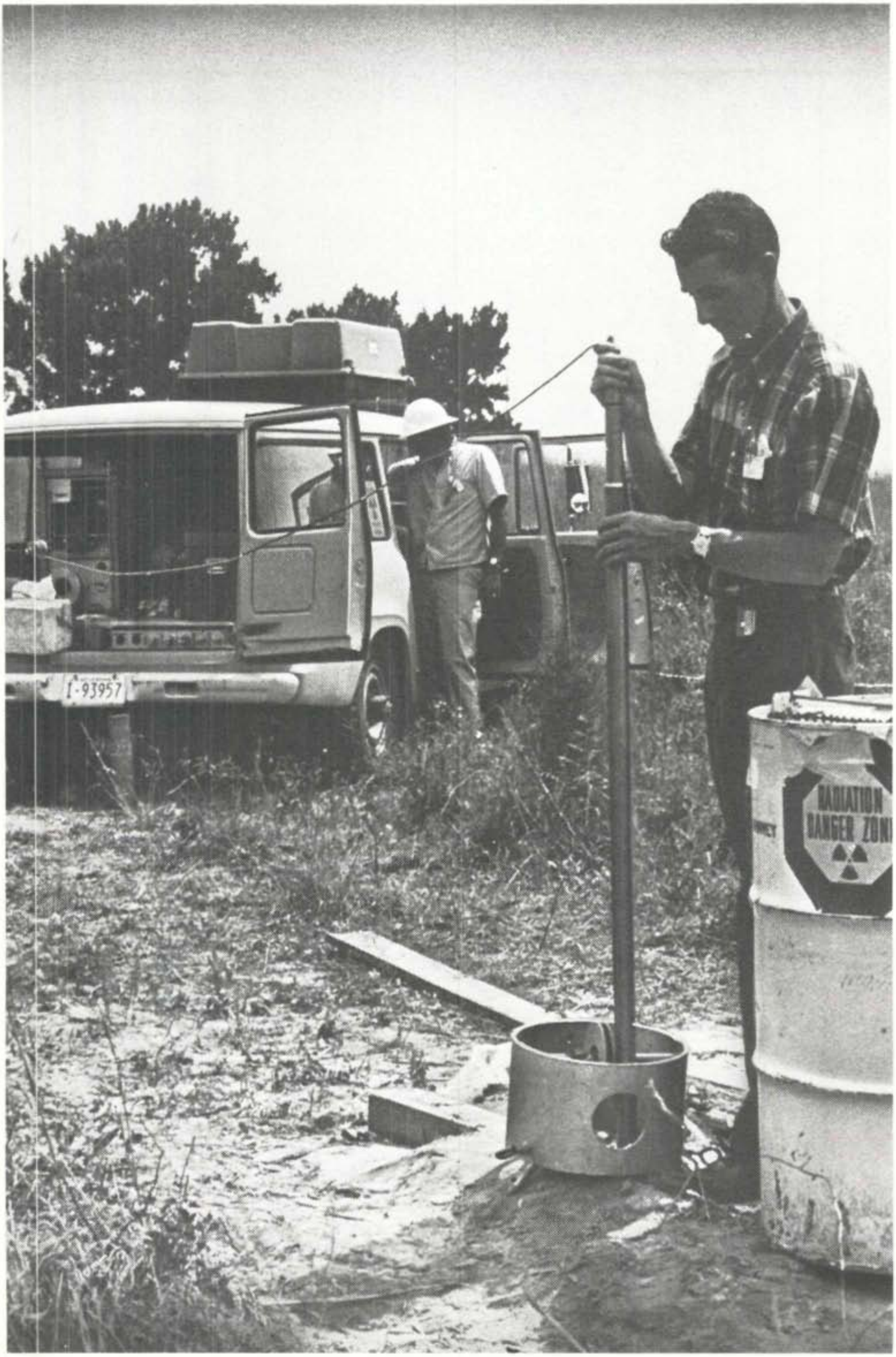
Isotope Ratios as Pollutant Source and Behaviour Indicators

Recent years have witnessed significant advances in isotope techniques for identifying origins and for studying the behaviour of trace contaminants and pollutants of the environment under actual existing environmental conditions. Improvements in the supply of stable isotopes and their labelled compounds, instrumental analysis and *information on stable or radioactive isotopic ratios of existing environmental* contaminants as a function of origin or behaviour have provided relatively new tools for the environmental scientist. While variations in natural or existing environmental stable and radioactive nuclides could be regarded as "background noise" in conventional tracer experiments they promised unique information about sources and behaviour to those who listened carefully.

The symposium was concerned with the exploitation of these advances in obtaining answers to the questions – where does a contaminant come from or, if that is known, what happens to it? The importance of these questions is nicely illustrated by the problem of mineral nitrogen – a valuable fertilizer in the right place at the right time – a pollutant when in the wrong place at too high concentrations – e.g. in lakes and drinking-water supplies.

An increasing weight (currently more than 30 M tons annually) of nitrogen is applied to the world's soils to meet growing world food needs. Rarely is more than half to applied nitrogen recovered in the harvested crop. The obvious first question arises: What happens to the missing half or residue? Half, incidentally, of a vital and increasingly costly agricultural input, especially for developing countries. How much gets returned to the atmosphere by soil "denitrification" processes? How much gets leached from the soil into local ground, surface, or even drinking waters? It has also been established that the levels of inorganic nitrate have shown a significant rise in certain ground and surface waters and in some cases already exceed WHO recommended limits for potable water. Thus, secondly to what extent – if any – are these increases due to fertilizer nitrogen applications? To what extent from animal or municipal waste? These questions are urgent and important, not only from the point of view of fertilizer conservation and pollutant potential, but because wrongly directed controls would be a danger "that vital agricultural practices might be impaired with little or no benefit to environmental quality".

A californium-252 source used by the US Geological Survey to determine the moisture content and porosity of rocks in a drill hole. Photo: Dupont de Nemours & Comp. ▶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RADIATION
DANGER ZONE

Useful and reliable answers to such questions can only be obtained under actual environmental and agricultural conditions over a sufficiently long period of time. Conditions, which, unfortunately, usually preclude the conventional use of radioactive tracers because of costs and real or imaginary radiation hazards. 34 papers were presented at the symposium and a final session was devoted to an overall appraisal.

Several papers dealt with the use of existing or environmental radionuclides for identifying or characterizing sources of environmental pollution as a result of nuclear power production or other nuclear processes. Studies of ^{90}Sr, ^{137}Cs, radioactive ruthenium ($^{103-106}$Ru) and radio-iodine ratios (^{129}I/^{127}I) in soil-plant-animal systems under "steady-state" conditions of environmental contamination suggested more reliable bases for predicting the movement of these radionuclides in agricultural food chains and correlating levels found with discharges. Isotopic ratios of krypton-85/tritium and radioactive isotopes of ruthenium were useful indicators of the various possible nuclear power reactor-, plutonium-processing plant- or atmospheric nuclear test-sources

An important point was the demonstration that trace radioactive contaminant behaviour in soil was a function of physical and chemical form, e.g., whether particulate, ionic or cationic. A paper on the use of ratios of stable sulphur-isotopes had similar implications on the role of particulates in the chemical behaviour of sulphur-dioxide in power plant smoke plumes.

Studies of the behaviour of tritium in trees indicated the importance of recognizing differences in the short term behaviour of environmental tritium in the free water compartment or labile water of foliage and the longer term behaviour of the so-called tissue-bound tritium.

The use of environmental isotope ratios of ^{12}C, ^{13}C and ^{14}C as indicators of the origins and behaviour of carbonaceous pollutants in atmosphere, soil and water was the subject of several papers. Of novel interest and potential importance was the possibility of characterizing sources of organic carbon compounds in food and drink water on the basis of ^{13}C, ^{2}H and ^{18}O ratios.

Several papers were concerned with the use of natural and artificially altered ratios of ^{15}N and ^{14}N for studying the important problems of the behaviour of agricultural fertilizer nitrogen in relation to its conservation as a vital plant nutrient and to its potential for ground water pollution (see above).

One paper demonstrated the use of the stable isotope sulphur-34 as a tracer of the fate of sulphur dioxide and its uptake by plants under field conditions where the use of radioactive sulphur-35 would be precluded — an important contribution to the problem of possible effects of sulphur dioxide on large areas of plant life.

Several papers confirmed accelerated progress in the preparation and use of stable isotopes as tracers under field conditions. These developments promised a major advance in the tools available for safe, effective and economical use as tracers under field conditions.

Some sophisticated experiments had shown that by double labelling techniques, e.g. methane as $^{13}C^{2}H_4$ the labelled molecule could undergo environmental isotopic dilution and still provide for detection with a sensitivity which could rival or even exceed that possible with a single radioactive label.

Several papers made principal or incidental references to advances in methodology. E.g. significant reduction of background radioactivity for the γ-spectrometric assay of radio iodine isotopes; the effective monitoring of ^{238}U by low-energy γ-ray spectrometry; improvements in the preparation of nitrogen samples for $^{15}N/^{14}N$ analysis; the practicability of multiple labelling of organic compounds with stable isotopes to provide for the detection of labelled molecules or fragments after dilution factors which could rival those obtainable in the use of radioactive isotopes; the use of $^{15}NO_2$ for the detection and measurement of NO_2 as an atmospheric pollutant.

While there had been a dramatic improvement in the availability of stable isotopes and their compounds and in the potential for their field use, further improvements were a function of demand. The effective use of stable isotopic tracers and reliable interpretation of data often required sophisticated methodology, instrumentation and experience. Research and monitoring programmes based on regional or international centres should, therefore, be encouraged. The Symposium had demonstrated clearly the importance and potentialities of a few stable isotopes as tracers. However, there were other elements where fractionation of the natural isotopes might justify an experimental extension of isotope concentration or depletion programmes, bearing in mind the likely increased costs and complexities with increasing isotope mass number. The field use of the stable isotopes ^{2}H, ^{12}C, ^{13}C, ^{14}N, ^{15}N, ^{17}O and ^{18}O as tracers was already economically and experimentally feasible. Such applications had some very important advantages over radioactive tracers. There was no radiation hazard. There was no effective time limit due to radioactive decay of the tracer. The use of multiply-labelled molecules permitted their identification and detection after isotopic dilution on a scale which could rival that of single radioactive tracers.