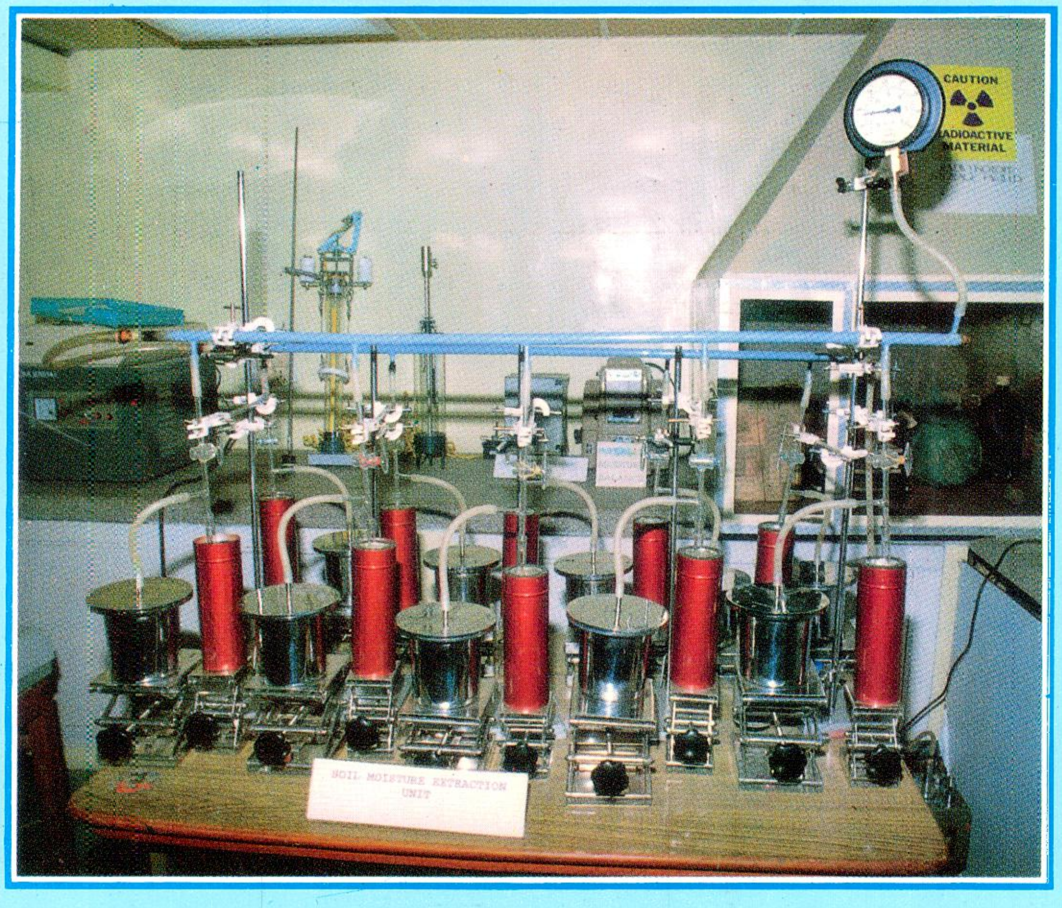
ISOTOPE HYDROLOGY



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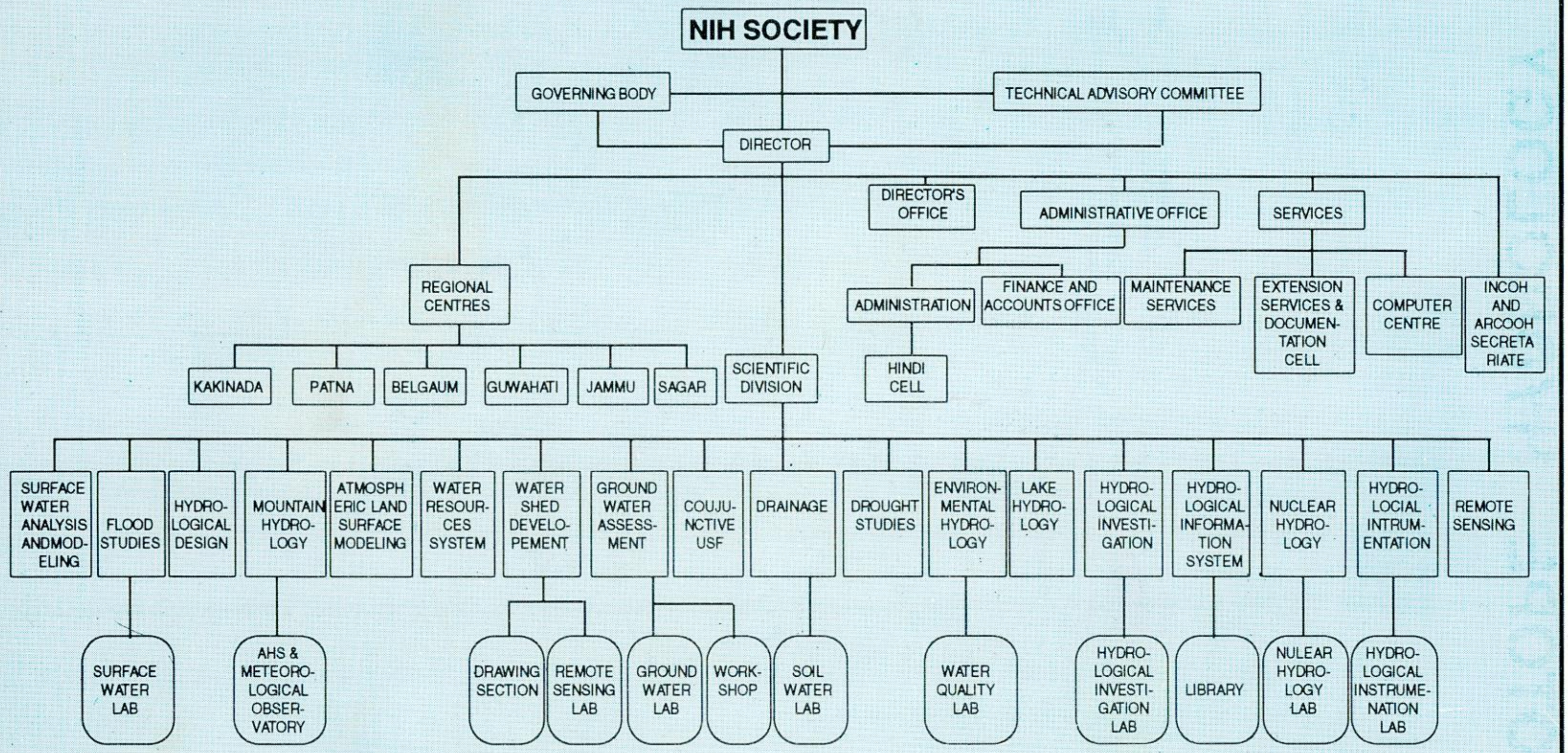

NATIONAL INSTITUTE OF HYDROLOGY, ROORKEE

ORGANISATIONAL STRUCTURE

ISOTOPE HYDROLOGY

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NATIONAL INSTITUTE OF HYDROLOGY
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FOREWORD

Water is vital to all forms of life on earth, from the simplest of living organisms to the most complex of human systems. Lack of fresh water to drink, for use in industry and agriculture and for multitude of other purposes where water is essential, is a limiting facto perhaps the most important factor- hindering developments in many parts of the globe. As population increases, the demand for water increases. And while the world's fresh water resources are not only distributed unevenly in space and time but also have finite limitation in terms of practical utilization. Water shortages currently affecting many areas are likely to spread, becoming far more prevalent during the next century. In many regions these shortages are likely to be increased because of climatic changes.

In these circumstances, improving knowledge and creating awareness of global water resources is indispensable for the well being of the mankind and for the protection of environment. Hydrology is the earth science which deals with the availability and variability in space and time of water resources. Hydrological problems requiring development and research are mainly related to quantitative assessment of surface and groundwater resources, their interaction, their space and time distribution, problems arising from water deficiency, and problems arising from water excess. Besides basic and fundamental research in scientific hydrology it is necessary to identify appropriate techniques for many practical field problems.

Isotope or nuclear technique is one such technique and has proved to be one of the reliable tool of easy and economical applicability. Sometimes the use of this technique is unique. In many cases this technique is of promise in confirming and complimenting data which have been gathered from other techniques. In number of cases the value of nuclear tracer logging as well as that of other technique is considerably increased by use in combination within the framework of interdisciplinary research. Realising the present and futuristic use of this important technique, it was considered appropriate to bring out this Information Brochure. The main purpose of the Information Brochure series to which this Brochure belongs, is to present information on a topical area as well as to provide information on hydrological technique for the use of interested persons/general public. This Brochure has been prepared by Dr. Bhishm Kumar and Sri Rm.P. Nachiappan of Nuclear Hydrology Division of the Institute. It is hoped that this series will furnish material of both practical and theoretical interest to water resources engineers and scientists as well as general readers.

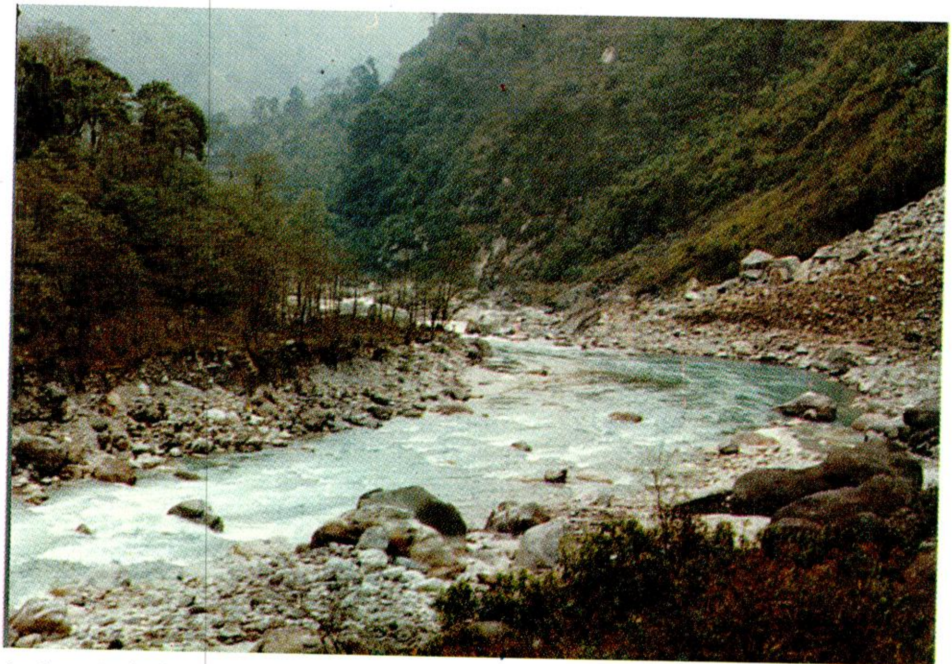
(S.M. Seth)
Director

INTRODUCTION

The total amount of water on this earth is virtually constant but its distribution over time and space varies to a great extent. Wherever people live, they must have a clean, continuous and ample water supply. The assessment of quality, supply, and renewal of resources is a well known problem, but it is becoming critical with the growth of population and rapid industrialization.

In the past few decades, sophisticated nuclear-hydrological instrumentation have been developed to measure accurately both radioactive as well as stable isotopes and accordingly various isotope techniques have been evolved. It is therefore, now very easy to find effective and useful information to solve many hydrological problems related to planning of agriculture, industry, and habitation using isotope techniques which were very difficult, sometimes impossible to tackle in the past.

Isotopes can play a vital role in studying the soil moisture variation, its movement and recharge through unsaturated zone. Origin, age, distribution of waters in a region including occurrence and recharge mechanism, interconnections between groundwater bodies and identification of recharge sources and areas can be easily studied using environmental isotopes. Isotopes can also be applied to study the dynamics of lakes and reservoirs, leakage/seepage from dams/canals, river discharge in mountainous regions, sedimentation rates in lakes and reservoirs, surface water and groundwater interaction and sources and tracing of pollutants including sea water intrusion and salinization mechanism. Snow and glacier melt runoff and snow gauging can also be done effectively using isotope techniques.



Isotope techniques can be used to study river hydrology in mountainous regions

Isotope techniques can be used as a tool to study the nature of a boiling well due to leakage from a reservoir

The use of isotopes in hydrology was started in early 1950's when the newtron scattering probe was introduced to study the soil moisture in unsaturated zone and the radiocarbon dating technique was employed for determining the age of groundwaters. After that a number of applications of isotopes were successfully tried and used to find the effective solutions of various hydrological problems in the developed countries. Later on the International Atomic Energy Agency (IAEA), Vienna, Austria, an independent intergovernmental organisation with in the United Nations System, took a leading role in the development and use of isotope techniques in hydrology. Now a days, isotope techniques are used frequently in the developed countries while their use in the developing counties is increasing slowly.

The applications of environmental isotopes had been initiated in India in early 1960's by the Tata Institute of Fundamental Research, Bombay to determine the age of groundwaters and recharge to groundwater bodies in Gujarat and Rajasthan. Later on Bhabha Atomic Research Centre (BARC), Bombay took lead to spread the use of isotope techniques in hydrology in India. Now a days, Physical Research Laboratory, Ahmedabad; National Geophysical Research Laboratory, Hyderabad; National Institute of Hydrology, Roorkee; Defence Research Laboratory, Jodhpur; Nuclear Research Laboratory, Indian Council for Agricultural Research (ICAR), Delhi; Centre for Water resources Development & Management (CWRDM), Kozhikode; UP Irrigation Research institute, Roorkee; UP Ground Water Department, Lucknow and few more central and state government organisations are actively involved in the isotope hydrology work in India.

WHAT IS ISOTOPE HYDROLOGY

Isotope Hydrology is a subject where isotopes play a leading role in understanding the water in hydrological cycle as well as many applications and research activities. A planned use of isotopes has proved to be advantageous in solving many hydrological problems and is being used as a powerful tool by the hydrologists. As a consequence, a new branch of application hydrology ISOTOPE HYDROLOGY has emerged.

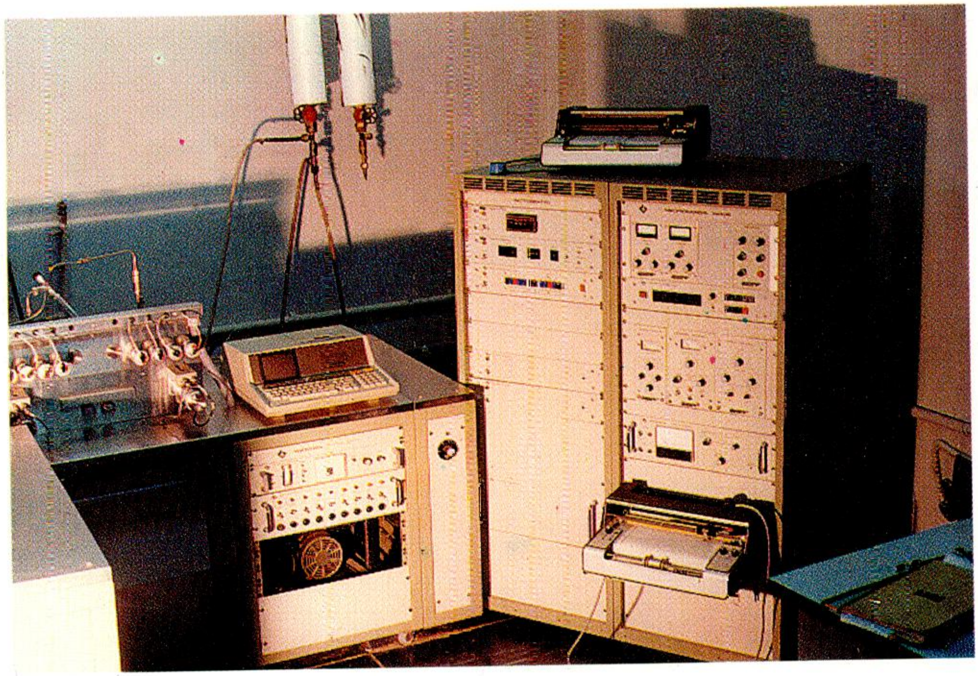
In other words, Isotope Hydrology is a branch of HYDROLOGY in which various investigations, which are otherwise not possible or very tedious to manage with conventional techniques, can be carried out with higher accuracy using various isotopic techniques employing radioactive and stable isotopes.

ISOTOPES

An isotope is the atom of an element having same atomic number (A) but different atomic weight (Z). Isotopes can be understood with the following illustrations, i.e., isotopes of Hydrogen, Carbon and Oxygen. The abundance of isotopes in nature is shown in bracket.

^{1}H - Normal atom of Hydrogen with Z = 1 and A = 1(99.985%)
^{2}H - Deuterium- a stable isotope with Z = 1 and A = 2 (0.015%)
^{3}H - Tritium- a radioactive isotope with Z = 1 and A = 3
^{12}C - Normal carbon atom with Z = 6 and A = 12 (98.9%)
^{13}C - A stable isotope of carbon with Z = 6 and A = 13 (01.1%)
^{14}C - A radioactive isotope of Carbon with Z = 6 and A = 14
^{16}O - Normal atom of oxygen with Z = 8 and A = 16 (99.76%)
^{17}O - A stable isotope of oxygen with Z = 8 and A = 17 (0.04%)
^{18}O - A stable isotope of oxygen with Z = 8 and A = 18 (0.2%)

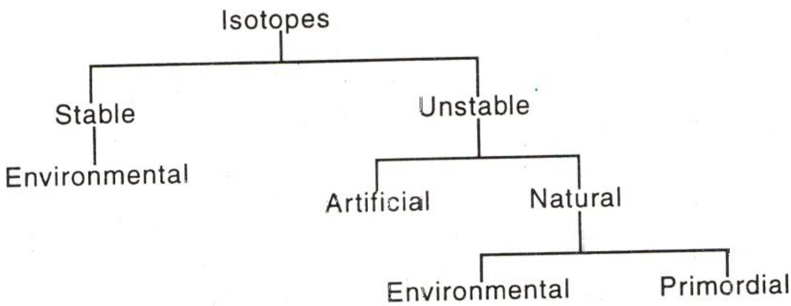
Ultra low-level liquid scintillation spectrometer for measuring very low-level activity of α & β radioisotopes including environmental tritium & carbon-14



Stable isotope ratio mass spectrometer for measuring $\delta^{18}O$ and δD

CLASSIFICATION OF ISOTOPES

The classification of isotopes can be shown by the following diagram



STABLE ISOTOPES

The stable isotopes are those which do not decay with time and are considered to be happy with their number and/or arrangement of protons and neutrons. The stable isotopes that are used for most of the hydrological studies are derived from environment. Hence, stable isotopes are also called as environmental stable isotopes.

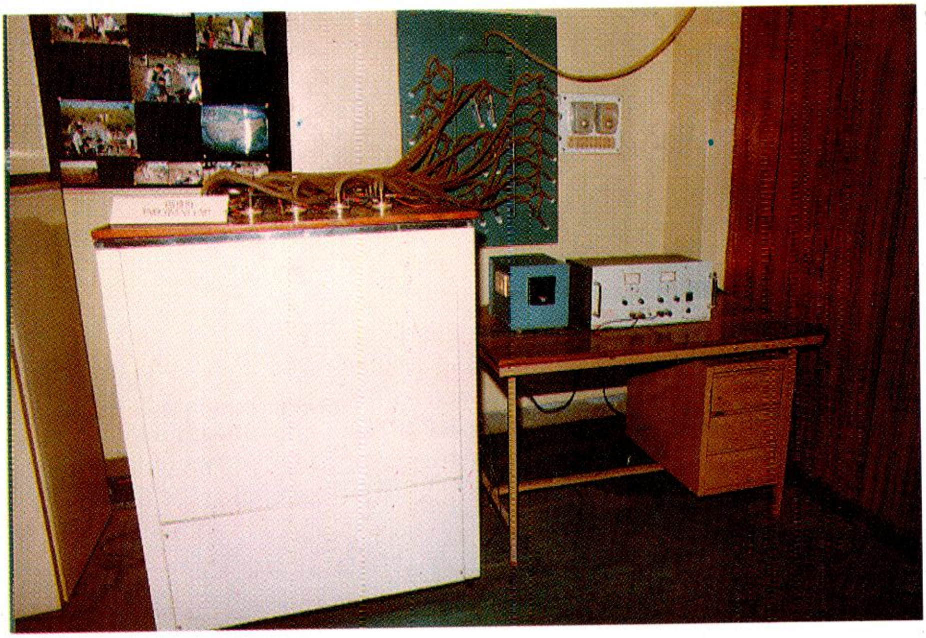
UNSTABLE ISOTOPES

Unstable isotopes, also called radioactive isotopes or radioisotopes, are those which considered energetically 'unhappy' with the number or arrangement of electrons, protons and neutrons. Therefore, they attempt to become stable either by spontaneously emitting different types of particles from their nuclei or with an accompanying loss of energy in the form of radiations. In doing so, they will change to another type of atoms which could be stable or radioactive atoms.

Natural unstable isotopes are those radioisotopes which are found in nature and produced by the natural processes. These can be of two types i.e., environmental isotopes produced by cosmic rays and primordial radioisotopes. The artificial radioisotopes are produced in laboratory or nuclear reactor under controlled conditions.

Radioisotopes emit alpha(α) particles, beta(β) particles and gamma(γ) radiations during their transformations from unstable to stable form. The α particle is a doubly ionized helium atom (made up of two protons and two neutrons) and owing to its heavy atomic mass (4), its penetration power is very low. The β particles are electrons ejected from the nucleus with energy range from few KeV to MeV and are highly useful for various hydrological investigations.

Normal liquid scintillation spectrometer for measuring α and β artificial radioisotopes



Tritium enrichment unit for enriching environmental tritium concentration

The gamma radiations are photons (electromagnetic radiations without mass) and have high penetration power, therefore, can be used as an important tool and find wide application in hydrology. The neutrons are emitted by many elements, when irradiated with alpha particles (emitted by some other element). Therefore, two elements are used (Ra/Be, Am/Be etc.) to get the neutron emission. Neutrons are used in hydrology as a tool to study the soil moisture variations in unsaturated zone.

Excessive exposure of radioisotopes can be harmful to humans, however we are accustomed to normal environmental radioactivity. Keeping in view the possibilities of excessive exposure of artificial radioisotopes while using them for various hydrological studies, investigators now prefer to use environmental isotopes. Nevertheless, the radioactive isotopes can be detected easily with comparatively cheaper instruments while very costly instruments are required for the measurement of stable isotopes.

ENVIRONMENTAL ISOTOPES

Environmental isotopes, both stable and radioactive (unstable), occur in environment in varying concentrations with respect to place and time over which the investigator has no direct control. The most commonly used environmental stable isotopes are Deuterium (D), Oxygen-18 (^{18}O), Carbon-13 (^{13}C) and radioisotopes Tritium (^{3}H) and Carbon-14 (^{14}C), Nitrogen-15 (^{15}N), Chlorine-36 etc.. Silicon-32 (^{32}Si), Caesium-137 (^{137}Cs) and Lead-210 (^{210}Pb) etc. are also used as environmental radioisotopes for few specific studies in Hydrology. Silicon-32

(^{32}Si) is potentially attractive because, its half life (100 yr) is between that of ^{3}H and ^{14}C. A number of measurements have been made in India but, it has not been used widely. Argon-39 (^{39}Ar) has also been investigated and research is still in progress, but the disadvantage of using both ^{32}Si and ^{39}Ar is that large amount of water (a few tons) is required to provide required amount of sample for measurement.

RADIOACTIVITY

The phenomenon of disintegration of unstable atoms to the stable form is called radioactivity. The unit of radioactivity is denoted by Curie (Ci) and one Curie is equal to $3.7 * 10^{10}$ disintegrations per second. In case of very low activity, it is also denoted by Becquerel (Bq) and one Becquerel is equal to one disintegration per second (1 dps). The activity per unit gram is known as specific activity and it is denoted by Curies or milli Curies or micro Curies per gram. The energy of disintegration or radiation is denoted by KeV or MeV.

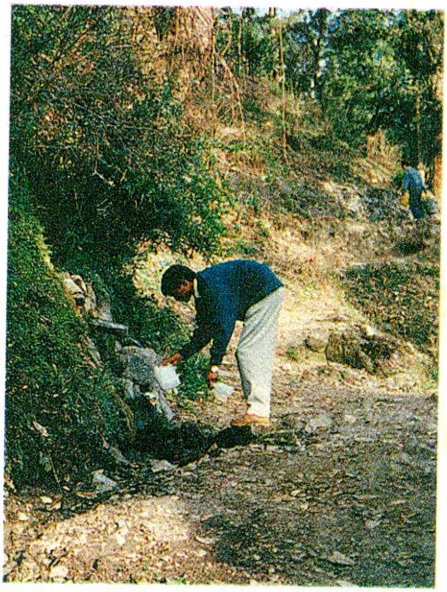
HALF LIFE

The time in which the radioactive element decays to one half (1/2) of its initial strength is known as half life. Different radioisotopes have different half lives and the decay rate is a characteristic property of an atom.

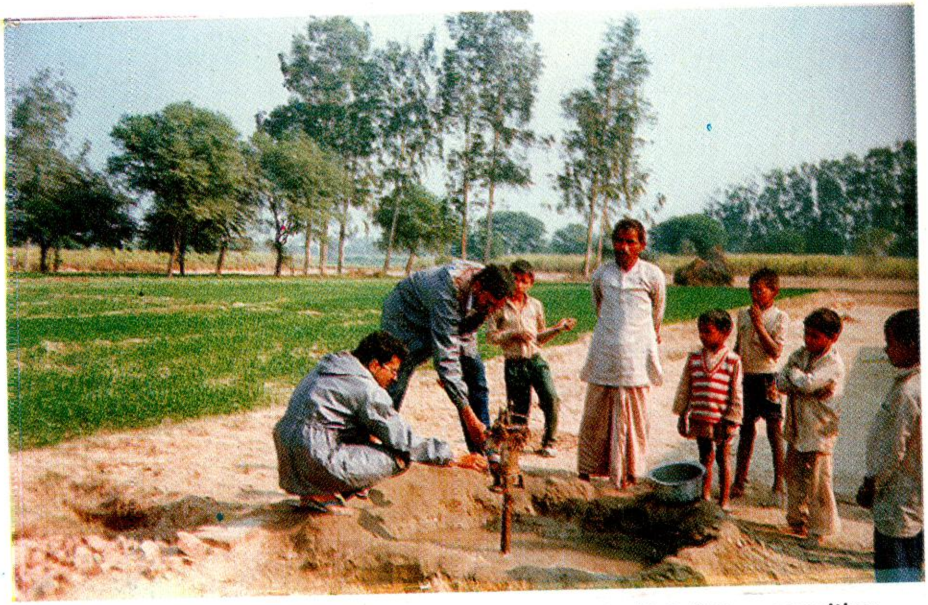
APPLICATIONS IN HYDROLOGY

Techniques using "environmental" isotopes are among those that meteorologists, hydrologists, and hydrogeologists use in the study of water. Study of the

Sediment cores for measuring rate of sedimentation



Spring water sampling for measuring environmental stable isotopes



Groundwater sampling for environmental isotopic (D & ^{18}O) composition

isotopes of oxygen and hydrogen in water, or of elements contained in dissolved salts which have the same behaviour as water, enable exact recording of phenomena affecting the occurrence and movement of water in all its forms.

Isotopic methods are normally used in conjunction with established conventional hydrological ones, so as to provide additional and valuable information for solving many hydrological problems. In recent years, in hundreds of difficult cases, isotopic methods have provided definite, satisfactory results.

The isotopic techniques can be employed in order to study the following aspects related with various branches of hydrology.

GROUND WATER

- Soil moisture variation, movement and recharge to ground water
- Origin
- Groundwater dating
- Distribution
- Occurrence and recharge mechanism
- Interconnections between groundwater bodies
- Identification of recharge sources and areas
- Data on lithology, porosity and permeability of aquifers
- Pollution source and mechanism

SURFACE WATER

- Dynamics of lakes and reservoirs
- Water balance
- Identification of recharge sources and areas

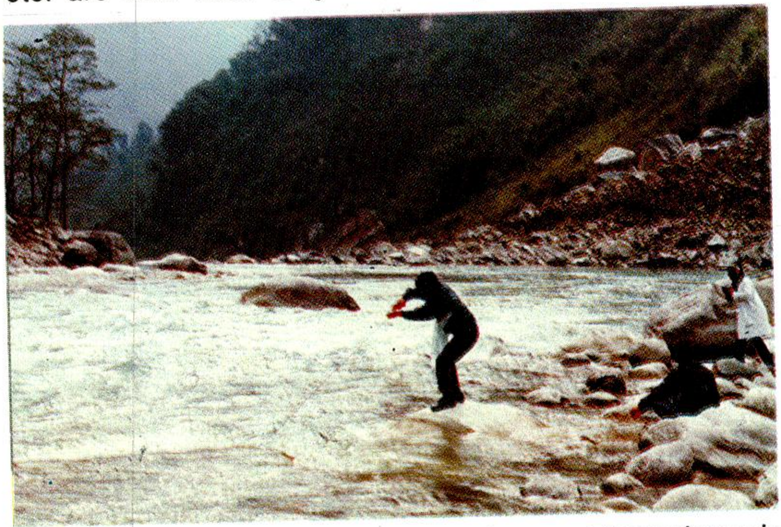
- Leakage through dams,
- Seepage to subways
- River discharge measurements
- Suspended and bed load sediment transport
- Sedimentation rate
- Evaporation/Evaportanspiration
- Surface water and groundwater interaction
- Sources and tracing of pollutants
- Snow and glacial melt runoff

METEOROLOGICAL

- Dispersion, transport and mixing processes on local, regional, and global scale
- Transport of water vapours
- Environmental pollution and mechanism
- Stratosphere-troposphere exchange

Artificial isotopes are used primarily to provide the necessary information to solve relatively local hydrological problems like leakage from dams / reservoirs or to define ground water protection zones. They are also used to identify water flow patterns in highly soluble and fractured rocks like karst where the flow of the ground water is relatively fast, measurement of discharge of streams in mountainous regions and estimation of recharge to groundwater due to rainfall and irrigation.

In recent times, more environmental isotopes are being used such as ^{18}O, D and ^{3}H which are all constituents of the water molecule. They are ideal tracers and since they are environmental isotopes, there is no difficulty in public acceptance. Similarly, other environmental isotopes like ^{13}C, ^{14}C, ^{15}N, ^{36}Cl, ^{137}Cs and ^{210}Pb etc. are also used to get useful hydrological information.



Sample collection during measurement of discharge of a mountainous river using radiotracer dilution technique

Isotope technique is of immense use in lake water balance and sedimentation studies

In many cases, still more information can be deduced by applying sophisticated mathematical models for the interpretation of tracer transport in ground water systems as well as the transport of solutes.

UTILITIES AND IMPORTANCE

Some examples which demonstrate the utilities and importance of isotope techniques, based on the important decisions that can be taken as a result, are as follows.

- By using isotopic methods in arid or semiarid zones, the age of the groundwater at planned industrial development locations can be determined. In a particular case, it was found to be 20,000 years old. This indicated that the groundwater had no contact with new resources and as it is not replenished, the area would run dry after a short time if this groundwater were to be tapped. Isotopic measurements were essential in avoiding a huge and useless investment.

- In the ground water of the Kalahari desert in Botswana, for example, the tritium concentration was found to be comparable to that in the sparse precipitation of the region. This confirmed that a fairly rapid recharge occurred and that the water could be tapped and used.

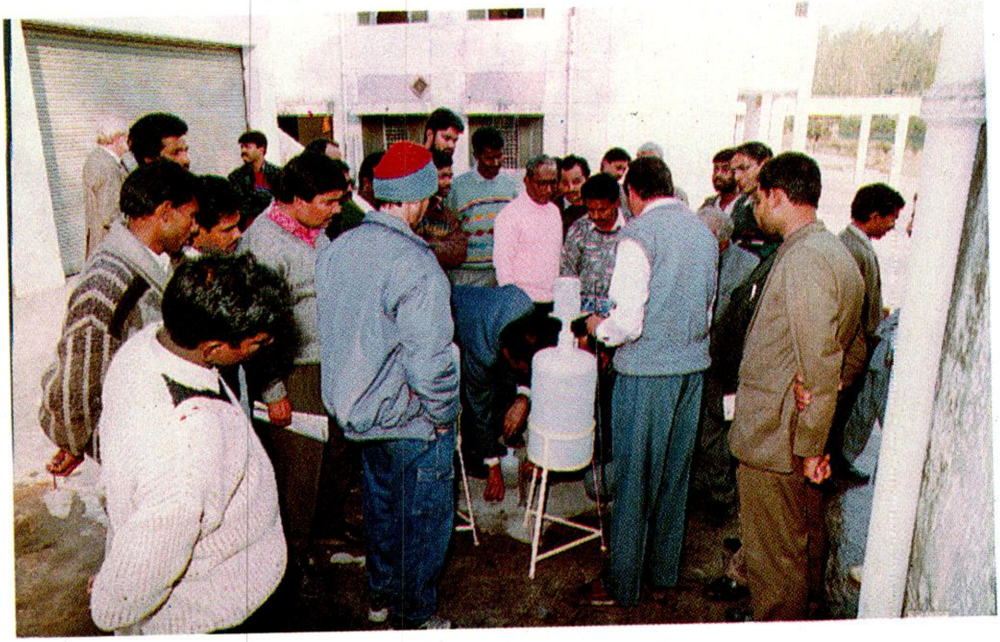
- A similar study was jointly conducted by IAEA and the National Water Organization, Mexico on recharge mechanisms in a coastal area south of Veracruz. Here, the rainfall is abundant but it is matched by evapotranspiration. The objective was to find out whether recharge by infiltration of local precipitation occurred. This was confirmed by isotope measurements.

Additionally, infiltration losses from a river crossing the coastal plain were estimated.

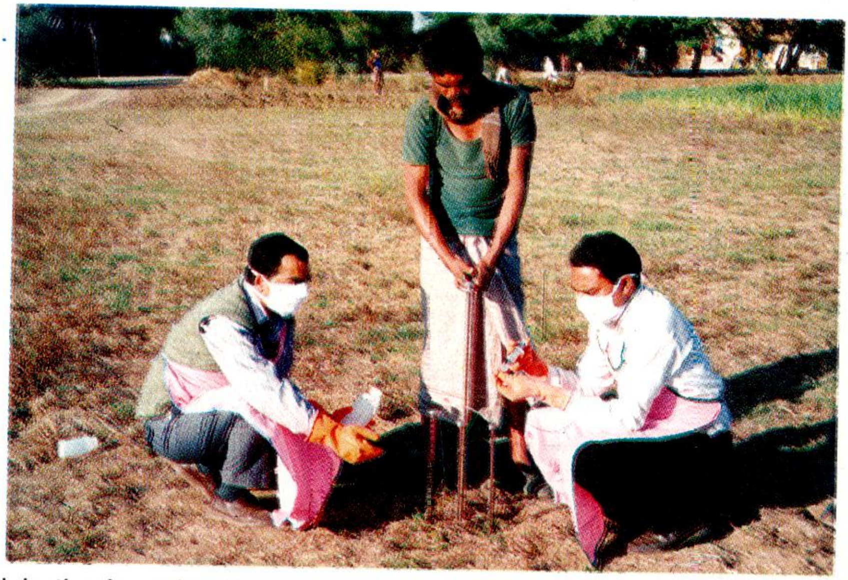
- Water pollution or high salinity is measured by chemical means, but the causes of the pollution often can be established by isotopic methods. One cause could be intrusion of sea water in coastal aquifers. With the help of isotopic methods, such sources of pollution were identified in Mexico, Crete and Portugal.

- For identifying some critical hydrological problems, only environmental isotopes can be employed where large areas are involved. The huge Continental Intercalaire Sandstone Aquifer of the Northern Sahara has been studied using isotopes which demonstrated the existence of leakage from the sandstone aquifer to another aquifer. In the eastern part of this aquifer in Tunisia, isotopes showed that water from this large aquifer leaks through a fault system. Hydrologists are often confronted with the problem of whether a fault is or is not a barrier to ground water movement.

- Dynamic sedimentological isotope measurements and erosion determination gave important answers in Singapore, where there were siltation problems in the harbour and the danger of erosion of newly recovered land from the sea to be used for the new Singapore airport. Using artificial radioisotopes, the existing problems could be solved, including the hazards of beach pollution, siltation of harbour installations, and possible erosion which could have endangered the new airport.



Sampling of groundwater for age determination using Carbon-14 dating technique



Radiotracer injection for estimation groundwater recharge due to rainfall / irrigation. Popularly termed as tritium tagging technique.

- Interactions between groundwater and aquifer matrix have been studied successfully using environmental and artificial isotopes. A technical cooperation project of IAEA in the alluvial aquifer of the Sebaco valley in Nicaragua brought solutions to many problems. The valley is surrounded by mountains of volcanic rocks and is crossed by two rivers. Environmental and artificial isotopes were applied and the findings established direction of flow in boreholes, recharge at the four edges of the valley, the downward vertical flow of water in boreholes, the age of the ground water, and lastly, it was established that no recharge occurred by infiltration of local precipitation.

- Isotopes have proved to be very useful in feasibility studies for projects. One example is a feasibility study to increase the storage capacity of a lake by constructing a dam in northern Ecuador. The first step was to establish the present seepage from the lake and evaluate the possible increased seepage owing to the much increased water pressure. The following information was obtained from the measurements.

- The presence of a clay layer was established.
- The presence of a sandy layer was established
- The lake does not contribute to a recharge of the sandy layer
- The sandy aquifer shows a significant contribution of water precipitated between 1970 and 1985.
- A vertical flow was established which could be attributed to discharge of ground water and
- Different permeabilities and therefore, different water velocities were established.

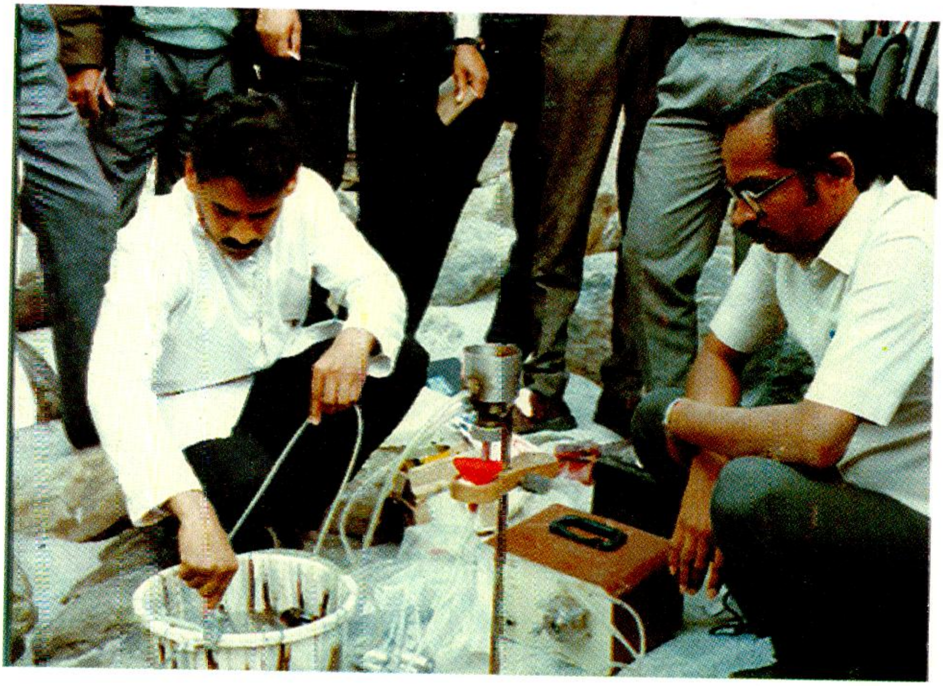
The conclusion was that significant seepage must be expected if the dam were to be built at this place. Another site would be a better choice for the construction of a dam, but even then it was thought that cement injections may be necessary.

- Environmental stable isotopes showed the degree of interconnection between the upper and lower groundwater zones under the Cauvery delta. This was to help in decisions on feasibility of artificial recharge of the groundwater system.

- Stable isotopic compositions of most Rajasthan groundwaters coupled with tritium and carbon-14 dating and paleoclimatological data show that the deep groundwaters are not being replenished in modern times. Therefore, an extra care is to be taken while taking any decision to develop an unused area for industrial or any other purposes in Rajasthan.

- Isotopes helped in identifying the source of heavy seepage encountered during tunnelling of the tail race tunnel in the Salal project in Jammu and Kashmir. River Chenab as well as a stream and a pond in the hillock were effectively ruled out. The seepage was traced to local rain waters, 10 to 15 years old. Result was the tunnelling could be continued safely and successfully.

Preparing radiotracer sample for injecting it into a reservoir to detect the leakage points in the reservoir



Preparing radiotracer sample for injecting it into a mountainous river to measure the river discharge

- A Systematic survey of the isotopic distribution (deuterium, oxygen-18, tritium and carbon - 14) in different horizons of Midnapore (West Bengal) groundwaters and their interpretation along with geological and geochemical data indicates that

  (i) present day sea water intrusion is limited and the groundwater salinity is mostly due to past sea water trapped in the sediments, and

  (ii) recharge occurs in the rock outcrops in Northern Midnapore.

- During the construction of a tailings dam at the Kudremukh Iron ore Project site, discovery of a fair-sized fissure in the rock put a halt on the work till the extent of the fissure was properly investigated. Injection of reactor produced radioisotope tracer along with copious amounts of water and then tracking the tracer in the water seeping into the valley downstream helped in demonstrating that the fissure was localised and posed no specific threat to the dam.

- Injected radioisotope tracer technique enabled the unravelling of seepage conditions in over ten different dams in the country, thus helping the engineers in devising effective remedial measures.

- A number of percolation tanks have been studied in Maharashtra to assess their effectiveness for artificial replenishment of local shallow groundwater bodies.

- In over 40 large scale studies in most of the major ports along the Indian coastline, vital information on movement of bedload sediments was provided for improved efficacy and economy in dredging operations.

- The source of seepage in Jhamar Kotra mines in Rajasthan was identified with the help of environmental isotopes as a result of recharge due to local rainfall and recirculation of the seepage water.

- The study of discharge of river Teesta at various locations during lean flow period helped in selecting the suitable sites and design of the mic ro-hydropower stations in Sikkim.

- The study of sedimentation rate and pattern in Lake Nainital including the information of sub-surface inflow and outflow using environmental isotopes has revealed the possible long useful life of lake against the short duration predicted using conventional techniques.

- The use of nuclear techniques in fields such as agricultural research supports environmental objectives. Agricultural production requires an adequate supply of water in soils. Neutron moisture gauges are used to improve traditional irrigation methods to cut total water use by some 40 percent. Different practices to increase water conservation in rainfed areas have been tested and have resulted in immediate practical application.

The distinct advantage of nuclear methods is that they can provide a definite answer within a short time and the measurements are relatively inexpensive.

It is obvious from above mentioned few examples that isotopes, environmental and artificial, can provide a definite answer to, or assist in solving, a number of important hydrological problems at a little cost.

TRAINING AND SUPPORT

International Atomic Energy Agency (IAEA), Vienna, Austria is a prime agency which takes care of training and financial support in the field of isotope hydrology at international level through Atomic Energy Agency of member countries that acts as a nodal agency. IAEA has close contacts with or established programmes in 85 member countries.

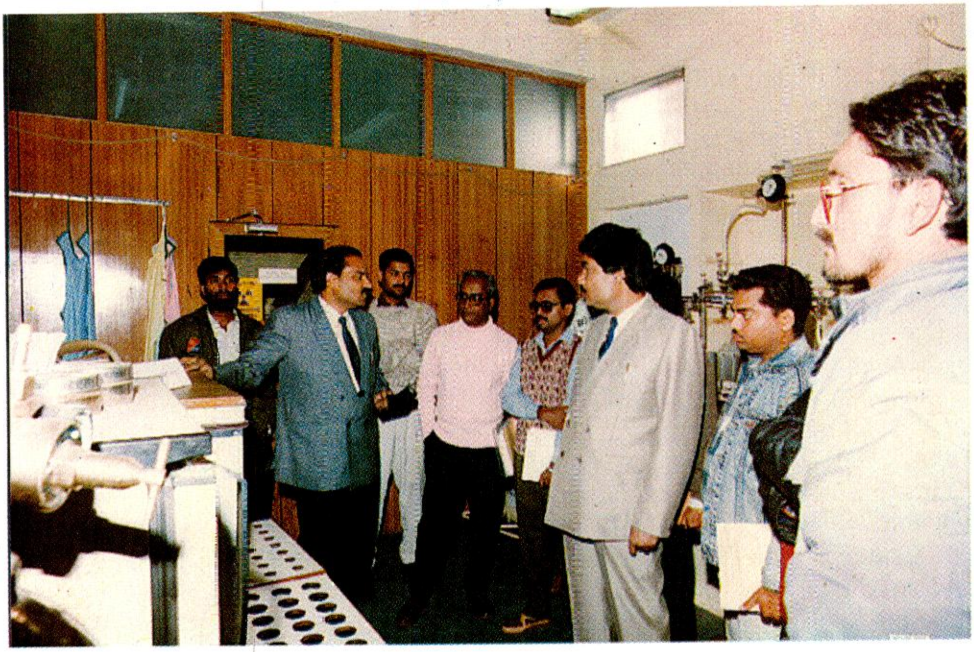
Govt. of India is also having close contacts with IAEA through Bhabha Atomic Research Centre (BARC), Trombay, Mumbai and necessary help / guidance is being provided by BARC to the individuals or organisations including the training on radiological safety aspects and radioisotopes can also be purchased from BARC, through Board of Radiation and Isotope Technology (BRIT).

The activities related with isotope hydrology were started in the year 1985 at National Institute of Hydrology (NIH), but in true sense, the Nuclear Hydrology Division associated with laboratory came into existance in the year 1993 at NIH, Roorkee for the development and use of isotope techniques in the field of hydrology and water resources.

The Nuclear Hydrology laboratory at NIH has facilities to measure the environmental isotopes like carbon-14, tritium, cesium-137, lead-210, radon-222 etc. using Ultra Low Level Liquid Scintillation Spectrometer. This equipment can also measure minute activity of silicon-32, strontium-89/90, radium-226/228 and many more. Cesium-137 and other gamma ray emitting radioisotopes are also measured by Multi-Channel Gamma-ray Spectrometer with HP-Ge and scintillation detectors. A Normal Liquid Scintillation Spectrometer is also available in the laboratory which is used for counting high activity beta emitting artificial radioisotopes. Tritium Enrichment Unit, Benzene Synthesizer, Soil Moisture Extraction Units and Vacuum Distillation Units are used as an accessary equipment in the laboratory. NIH provides an opportunity to its scientists to visit advanced nuclear hydrology laboratories in the developed countries and also to get training at various institutions abroad.

NIH also organises training courses / workshops to transfer basic and latest scientific knowledge about the use of isotope techniques in the field of hydrology and water resources. Such workshops are open to the field engineers and academicians. Field and laboratory visits are also organised for trainees during the training.

A view of the training workshop on isotope techniques to hydrology, organised in the year 1991 at NIH, Roorkee



Demonstration of the use of nuclear instruments in the Nuclear hydrology Laboratory at NIH during a training course

Normally, the training courses are organised at NIH but keeping in view the convenience of the field organisations, training courses can also organised at the requested places in the country.

RISK IN EVERYDAY LIFE

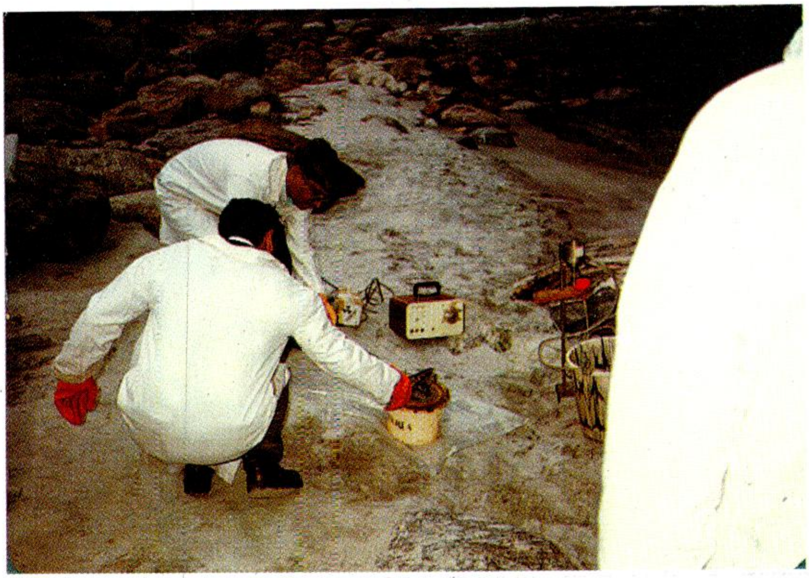
Every one is exposed to radiation and for most of the people nature is the largest source of exposure. We all also face risks in everyday life. Some of these risks can be avoided and others reduced. It is, however, impossible to eliminate all risks.

Some risks are imposed on individuals by the society in which they live. The use of coal, oil and nuclear energy for electricity production, for example, creates some risks which are inevitable, and others which may be reduced by pollution control measures. In general, society accepts such risks balancing them against the usefulness. The principal risk faced by an individual is the exposure to carcinogenic pollutants - of which radioactive effluent are only one form. This is not the only potential effect of exposure to pollutants. However comparatively, more is being learned about radiation and its effects on health, but they are reasonably well understood.

Clearly, we need to know what risks we are exposed to and how important each is. It is thought, for example that tobacco smoke and chemical pollutants in the atmosphere of industrial cities cause roughly 25% of all fatal cancers; another 35% may be attributed to dietary factors, and 20-30% to other environmental causes. A large part, perhaps 90% of the increase in lung cancer deaths over the past 50 years may be attributable to smoking alone. The remaining 10% may be caused by general atmospheric pollutants such as discharges from domestic and industrial furnaces, exhaust fumes from gasoline and diesel engines, dust and fumes from rubber tires, asphalt, paints, industrial chemicals and so on. Low-level radiation can only be a very small contributor to the total.

In case of use of isotopes for hydrological studies, environmental isotopes do not impose any threat to the health of human being because either they do not emit any radiation (stable isotopes) or they have very low activity (environmental radioisotopes) which we experience daily in our normal life, without being used isotope techniques. However, in case of use of artificial radioisotopes for hydrological studies, some precautions are required to be taken which can be considered similar to the precautions that we take while moving on a highway or while operating electric appliances. Although, these precautions can be taken by applying a simple common sense, yet when a person intends to apply isotope techniques using artificial radioisotopes, he/ she is supposed to undergo a specific training on radiological safety aspects. Therefore, for a person who knows that which type of activity (radioisotope) is required, how much activity is required, how to handle it and which type of precautions are to be taken at the time of using the activity, including the later date considerations, there is no risk involved in using isotope techniques, even with artificial radioisotopes.

Radioisotopes are properly packed and labelled for transportation and use in fields



Handling of high activity radioisotopes during their use for field experiments

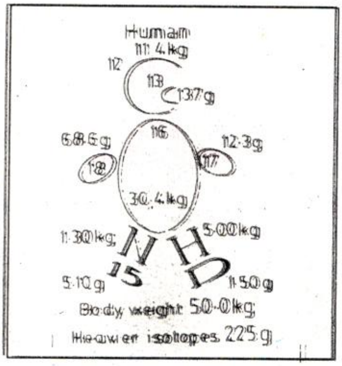
IMPORTANCE AND PERSPECTIVE

Some people may think that certain activities are unnecessary and that any risk associated with them could be removed simply by eliminating them. Consider the case of the nuclear power industry. Nuclear power plants and other nuclear installations release small amounts of radioactive material in the course of normal operation. They therefore contribute to our total exposure to low-level radiation - on average, in a western industrialized country, about one seven hundredth of the total (a little more than a tenth of one percent). They may account for about one seven hundredth of the health effects attributable to all natural and man made radiation. If there were no nuclear industry, the total number of health effects would be reduced only by this amount but, the life that may be affected in the shortage of electric power can be easily thought of by comparing the situation in the undeveloped and developed countries. Similarly, the use of isotopes in hydrological studies is based on the comparative benefit and loss. However, the use of artificial radioisotopes may be thought of on this ground, but the use of environmental isotopes should be increased as much as it can be, because these isotopes are available free of cost in the nature and we can study many important hydrological features and phenomenon by using them.

REMARKS

- More is known today about the risks of exposure to radiation than about those of practically any other physical or chemical agent in our environment
- The isotopes techniques are considered as the special techniques, therefore, their use is advised where either the igher accuracy is required or the conventional techniques fail or their use is not found cost and time effective.

- The use of environmental isotopes is totally risk free. The human body contains substantial quantities of stable isotopes, as depicted in this diagram. A person who weighs 50 kilograms, for example, has 225 grams of the heavier isotopes : hydrogen-2, carbon-13, nitrogen-15, oxygen-17 and oxygen-18, in case of normal growth.



(Credit : Dr. Wada, Mitsubish-Kasai)

- We are exposed every day to low-level radiation from natural and man made sources in our environment. Various ways of relating the dose received to health effects have been proposed. It is very difficult to verify any one theory conclusively.
- The health effects of exposure to radiation are not unique. The effects that can be attributed to low-level radiation are also known to be caused by a large number of other agents. The risks of radiation exposure to low-level radiation should not be disregarded; but it must be recognized that the risks to health posed by some of these other agents are much greater. Many more are almost unknown.

Remote operation of very high activity of radioisotopes to avoid health hazards

NATIONAL INSTITUTE OF HYDROLOGY
MAJOR LABORATORY FACILITIES AT ROORKEE
CAPABILITIES

COMPUTER CENTRE

* Analysis of hydrological data
* Data storage & retrieval system
* Development of mathematical models
* Development of softwares
* Implementation & application of softwares developed elsewhere salinity,

GROUND WATER

* Infiltration rate measurement
* In-situ soil density measurement
* Soil density measurements
* Soil sample collection

HYDROLOGICAL INSTRUMENTATION

* Collection, transmission and processing of hydromet data
* Design & development of various hydromet instruments and data acquisition system for field measurement

HYDROLOGICAL INVESTIGATION

* Flow/discharge measurement
* Infiltration rate measurement
* Measurement of water level in wells
* Water sampling from rivers, lakes etc.

NUCLEAR HYDROLOGY

* C-14/H-3 dating of ground water
* Discharge of rivers
* Ground water velocity measurements
* Leakage/seepage detection from dam / reservoir
* Environmental tritium enrichment
* Recharge to ground water
* Soil moisture measurement
* Sedimentation in water bodies

REMOTE SENSING APPLICATI

* Groundwater zonation mapping, plain mapping, land use, sedimentation, snow cover mapping, soil erosion, visual and digital image processing for water quality water logging etc.

SOIL WATER

* Determination of soil molsture characteristic curves (0.1 to 15 bar)
* Determination of soil suction (0 to 0.85 bar)
* In-situ soil moisture measurement
* In-situ soil salinity measurement
* Permeability measurement
* Sampling in soft & hard soil
* Sedimentation/wet mechanical analysis of soil

WATER QUALITY

* Analysis of organic carbon, inorganic carbon, total carbon
* Analysis of pesticides & other organic compounds
* Bacteriological analysis samples
* Field measurement of pH, conductivity, anions and trace elements

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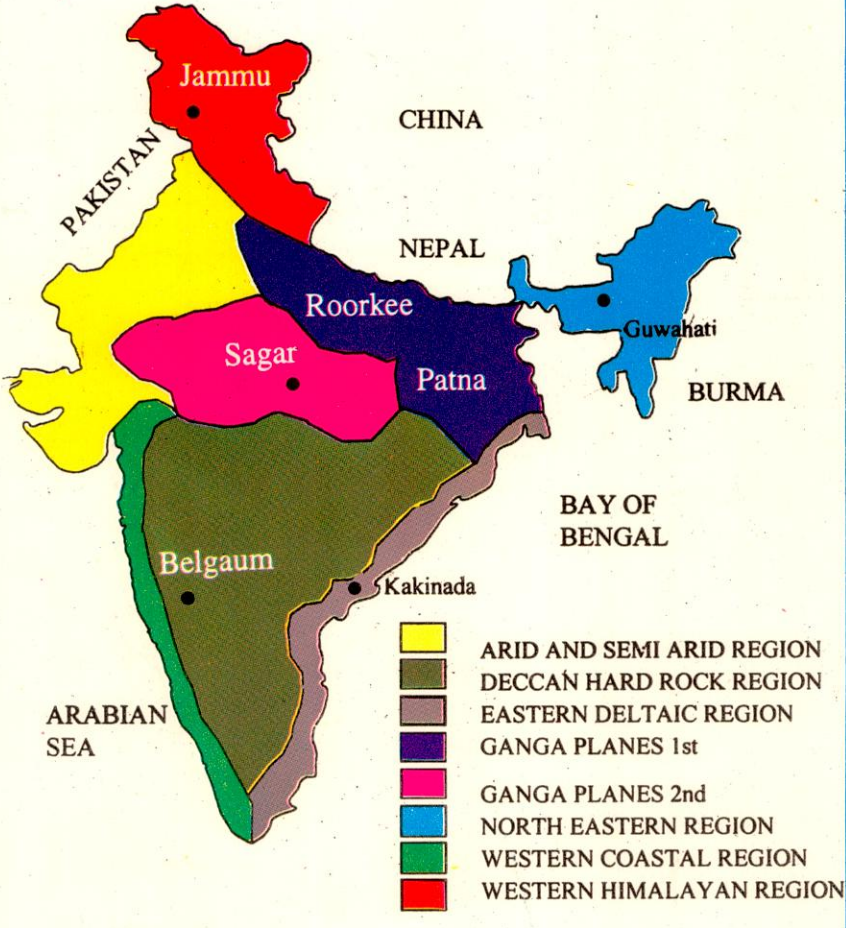
In addition, Regional Centres of NIH at different locations are well equipped to carry out computer, laboratory and field oriented studies relating to

* Hydrological modelling & analysis
* Digital image processing and GIS
* Ground water exploration
* Hydro-meteorology
* Remote Sensing applications
* Soil moisture measurements
* Soil sampling & analysis
* Water quality

REGIONAL CENTRES OF NATIONAL INSTITUTE OF HYDROLOGY



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