

# Radiation in Everyday Life



**Water  
Technology**



**Nuclear  
Medicine**



**Biogas  
Technology**

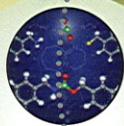


**New Age  
Security  
Systems**



**BRIT**

**Board of Radiation  
and Isotope  
Technology**



**Radiotracers  
Applications**



**Isotope  
Hydrology**



**Nuclear  
Agriculture**



**Radiation processing  
for Food  
Preservation**



### Repaying our debt to Nature

Bhabha Atomic Research Centre has pioneered a biogas technology popularly known as Nisargruna. Nisargruna literally means repaying our debt to the nature. Nisargruna is an environment friendly technology to decompose bio degradable waste and produce biogas and organic manure. BARC has developed a two stage digestion process to treat the waste. In the first step, the waste is crushed with the mixer grinder, mixed with hot water from a solar heater and aerated with air from an air compressor. This process breaks down complex bio molecules into smaller organic molecules. The slurry formed in the first stage is digested by methanogenic bacteria in the second stage to produce methane rich bio gas. The biogas generated is recirculated to multiple chambers in the second stage, resulting in biogas with a high concentration of methane. Biogas can be a substitute for LPG in the kitchen or can be converted to electricity by a genset.

The use of Nisargruna technology, originally conceived for the biodegradation of segregated kitchen waste, has now been adapted to slaughterhouse waste, fish and poultry waste, food processing waste and agricultural produce waste like oil cake. A Nisargruna biogas plant can produce 60 to 80 meter cubes of biogas from every metric ton of organic waste processed. This is approximately equal to 1½ cylinders of LPG or 80 units of electricity. 80 to 100 Kgs of high-quality organic manure from every metric ton of organic waste processed is a valuable by-product. Nisargruna plants have a long life time and requires minimum maintenance. The first plant was set up in 2002, is still operational at Anushakti Nagar, Mumbai. Subsequently, more than 100 Nirsargruna plants have been installed across the country. Modified compact versions of Nisargruna made of metal or high-density plastic components have been designed and installed in corporate offices for processing canteen waste.

Nirsargruna has been one of the highly visible and successful contributions of DAE for rural and urban waste management and now, an important contributor to the Swachh Bharat Mission of the Government of India.

## Biogas Technology



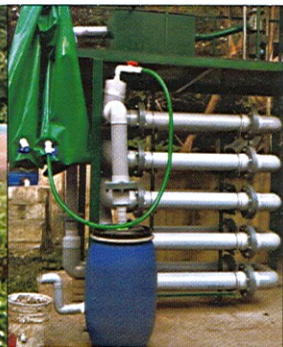
Biodegradable agricultural wastes



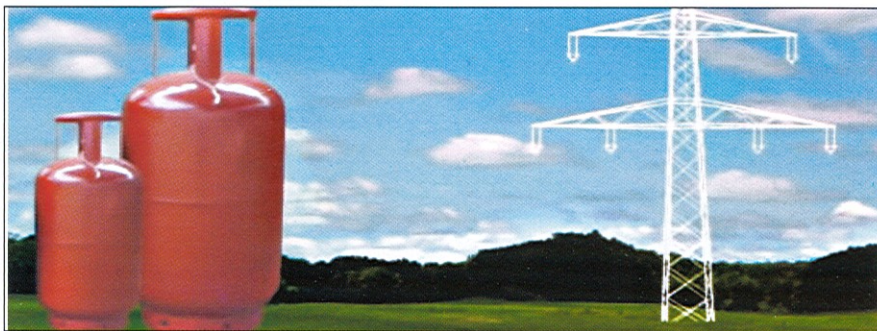
Segregation of kitchen vegetables



Nisargruna Biogas plant



Biodegradable Garbage Converter



Applications of biogas technology

# **BRIT** A Bouquet of Radiopharmaceuticals

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## Production & Marketing

The Board of Radiation and Isotope Technology or BRIT as it is commonly known, is a way of DAE dealing with the production and marketing of radiation sources and radio pharmaceuticals for various applications. BRIT supplies Cobalt 60 gamma source, used in Bhabhatron, sludge hygienisation plants, food irradiation facilities and mutation breeding experiments. The other most important mandate of BRIT is the supply of radiopharmaceuticals for diagnostic and therapeutic purposes which are manufactured in state of the art facilities using remote operations. Iodine 131 capsules for diagnosis and treatment of thyroid related disorders is an important product.

The manufacturing process involves the filling of the capsules with the anhydrous powder and transferring them to a shielded hot cell for the remote condition of Iodine 131 solution. After measuring the activity dispensed, the capsules are transferred to a shielded lead box, sealed, labeled and packed for transport. BRIT also manufactures Technetium 99m based radiopharmaceuticals in clean laboratories in the form of cold kits using sterile experiments and containers to eliminate microbial contamination. The final product is delivered in the form of freeze dried powder. The Technetium 99m generator manufactured by BRIT is a device containing alumina columns loaded with the parent product Molybdenum 99. Technetium 99m which is the daughter product is then built from these columns by the end user using saline solutions. The extracted Technitium 99m is then incorporated into the radiopharmaceuticals. BRIT also supplies radio immunoassay kits to diagnostic centers all over India. These RIA kits containing the labeled and unlabeled antigens as well as

the antigens specific antibodies are manufactured in an ISO certified laboratory of BRIT. The manufacturing procedures at BRIT are subjected to rigorous quality control protocols using state of the art equipments to ensure the purity and sterility of the radiopharmaceuticals. BRIT plays a vital role in the use of nuclear medicines and radiation therapy procedures for disease diagnosis and is regarded as an important contributor to the health security agenda of the nation.

### A Bouquet of Radiopharmaceuticals



Bhabhatron - one of the applications of Cobalt 60 isotope



Iodine 131 capsule preparation in shielded hot cell



Iodine 131 in a shielded lead box, sealed, labeled and packed for transportation



Technetium 99m radiopharmaceutical preparation



## Nuclear Medicine

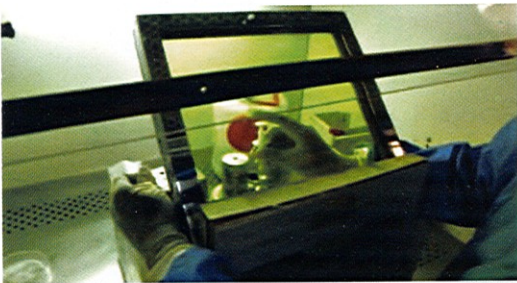
### Care to Cure

Radiation Medicine Centre or RMC in short, is a Division of BARC instituted by Dr. Homi Jehangir Bhabha in the year 1963 for using radioisotopes in diagnostic and therapeutic procedures as well as for carrying out training and research towards promoting nuclear medicine in India. A typical day at RMC starts early with patients reporting to OPD. While the patients are waiting to be assigned to clinic, the radio pharmacy unit of RMC is already busy preparing radiopharmaceuticals using radio isotopes made in the Dhruva reactor and processed at radiopharmaceutical division of BARC. The country's first 60.5 million electron volts cyclotron and automated radio chemistry synthesis module is engaged in making Fluorine-18 based PET pharmaceuticals. Patients are examined by the doctors and moved to respective units by administering the recommended treatment. For bio imaging, patients are injected with an appropriate radiopharmaceutical to image the suspected diseased organ such as liver, lung, kidney, bone, heart, brain or thyroid. An abnormal distribution of radiotracer is associated with characteristic organ pathology which helps in the diagnosis of the disease. Fluorine-18 FDG PET tracers are useful in diagnoses of cancer metastasis and neuro psychiatric studies. Radio Iodine therapy is given for thyroid cancer and hyper thyroid patients. RMC has the largest registry of thyroid cancer patients.

Theranostic pairs of radiopharmaceuticals intended for use in diagnosis and treatment of neuro endocrine and prostate cancers have been recently developed and used in RMC. Thyroid function test prescribed for patients are routinely carried out

using indigenously developed protocols by automated radio immunoassay. RMC also has an HRD programme, which conducts MD courses in Nuclear Medicine for medical doctors, as well as Diploma in Medical Radioisotope Techniques for nuclear medicine technologists to work in nuclear medicine centers. The primary mandate of the Department of Atomic Energy in providing treatment at affordable cost has been made a reality by nuclear medicine procedures developed at RMC. RMC is today one of the leading centers of nuclear medicine practices not only in India but also in Asia.

### Nuclear Medicine



Using radio isotopes in nuclear medicine



Applications of radio pharmaceuticals to diagnose and treat the diseased organs of the human body



## Water Technology

### The Elixir of Life

Water is the elixir of life and availability of clean drinking water is a prerequisite for leading a healthy life. Microbial contamination of drinking water, contamination from impurities and salinity of ground water being caused due to over exploitation and sea water intrusion are all matters of concern. Finding economical solutions to make clean drinking water available to the common man is one of the objectives of Department of Atomic Energy. BARC has developed several economically viable desalination and water purification technologies to serve households, communities and industries. One of the most commonly used products is domestic water purifier developed by BARC.

It eliminates commonly occurring microbial contamination. Ultra filtration membranes have been developed for removal of arsenic fluoride and iron from ground and surface water to make them potable. Technology has also been developed for the removal of hardness using charged nano filtration membrane modules. Technologies for desalination of sea water by thermal as well as membrane based methodologies have also been developed by BARC. The 1,000-liter- per- day capacity unit has been commissioned at Kalpakkam and is producing potable water with total dissolve solids less than 50 parts per million. BARC has developed a simple, low-cost membrane pouch for use in disasters caused by natural



calamities. It converts contaminated water into water which is safe for human consumption. The vast array of water technologies for a variety of applications serving rural, urban and industrial sectors is a great contribution of BARC to the needs of the nation.

## Water Technology



Domestic water purifier with ultra filtration membrane



Nanofiltration membrane



Desalination plant set up at Kalpakkam



Membrane to convert contaminated water into potable water



## Nuclear Agriculture

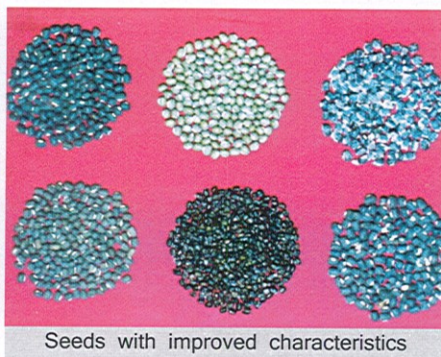
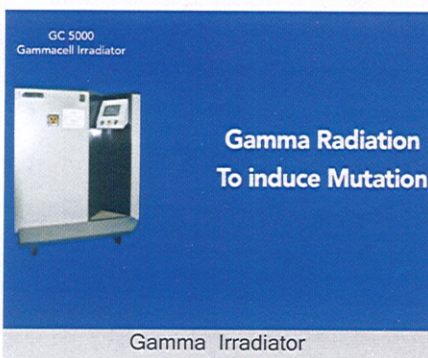
### Standing by our farmers

India has progressed from being a net importer of food to become one of the largest producers of food. However, India still lags behind many countries in terms of yield per hectare due to poor seed quality. Characteristics and traits of living species are determined by the genetic makeup. Small genetic variations can lead to substantial differences in the same species. Genetic changes are induced by nature leading to improved species over a millions of years, however genetic changes can be accelerated by gamma irradiation. BARC uses controlled low level irradiation to induce accelerated mutation in seeds leading to improved characteristics such as rate of yield, ability to withstand extreme weather conditions, resistant to pests, early maturation and resistance to lodging.

The seeds with improved characteristics are taken through five to seven generations to stabilize the changes. Such improved characters are then transferred to cultivated varieties by breeding to generate mutant varieties. After rigorous testing at multiple locations, the improved seeds are then released to the agricultural community. BARC has developed more than 50 varieties of the seeds mainly oil seeds, pulses and cereals. The improved variety of the Raj rice with early maturity and ground nut seeds with 4 times of the yield per hectare are in wide use today. Numerous varieties of groundnuts, red gram, black gram, green gram, jute and rice developed by BARC are widely used and are in great demand among the farmers in various states. India is one of the leading countries in the use of radiation technologies for improvement of agricultural

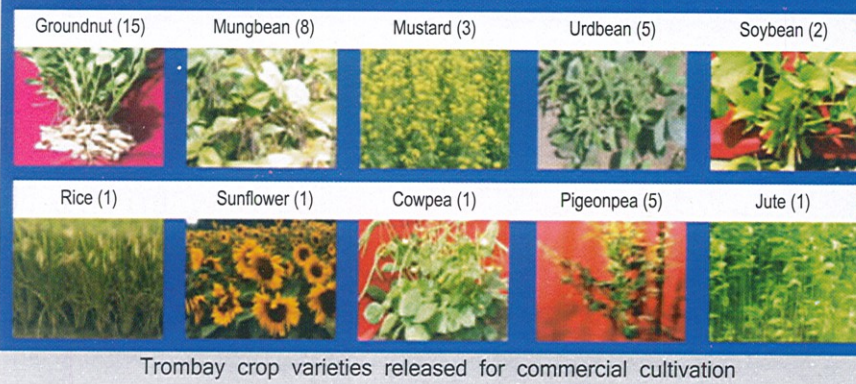
products. This has made a significant difference to the farming sector in the country and the economic well being of the farmers.

## Nuclear Agriculture



### Trombay (BARC) Crop Varieties Released for Commercial Cultivation

- More than 50 crop varieties released for commercial cultivation in the country
- Some of the varieties are very popular and grown extensively.
- Improved characters include higher yield, earliness, large seed size, resistance to biotic & abiotic stresses.





## New Age Security Systems

### Protecting our Vital installations

Bhabha Atomic Research Centre has developed a range of security systems for the protection of vital and sensitive installations of the organization. The physical intrusion detection system developed to detect intruders entering a restricted zone is one such system. The system deploys two cameras to generate a stereoscopic vision of any object or a person entering a restricted zone. Virtual boundaries created by algorithms immediately flag any intrusions. This method will also be well suited to detect and classify flying objects such as drones and therefore suitable for the deployment at remote locations.

Security can be further augmented by a piezo electric based intrusion detection system comprising piezo Resistive Sensors developed by BARC embedded into floor tiles and concealed under mats placed at suitable locations. A person stepping on the mat, generates a signal in the control room and alerts the security personnel. The system is customizable to suit the selected locations and offers a low cost and reliable solution for intrusion detection. A hand based multi biometric fusion system for access control of critical areas has also been developed by BARC. The person places his hand into a compact biometric measurement module. Access is granted after successful verification of the fingerprints, palm print and hand geometry of the person. This system is highly reliable due to the multifactor authentication process used for granting access. An abandoned package detecting system has been developed to identify abandoned package and object. In the event of the object remaining stationary for a specified duration, the system generates a visual and audio warning to alert the security personnel. The system can also trace the person abandoning

the object from the video stream. This serves to quickly resolve the matter with a minimum of disruption to activities. The development of in-house technologies and trustworthy systems by BARC is an important contribution to enhancing the security arrangements of the organization as well as home land security.

## New Age Security systems



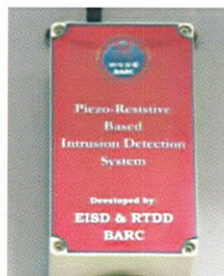
Physical intrusion detection system



Compact Biometric system



Piezo electric based intrusion detection system



Systems to detect flying objects and abandoned objects & package



## Radiation Processing for Food Preservation

### Supplementing the Food Basket

India loses about 20% of the food due to lack of storage infrastructure. Insects and microorganisms are primarily responsible for spoilage of food. Warm and humid climate in India is favorable to their growth. Radiation processing of food by gamma radiation is an internationally accepted, safe and cost effective solution to preserve food products over a long duration. More than 50 facilities have been established across the country to process food products using gamma ray based technology. Low doses of radiation delay ripening of mangoes, prevent the sprouting of onions and potatoes and disinfect cereals and pulses. Slightly higher doses can prevent spoilage in spices, herbs and minimally processed vegetables. Radiation processing techniques have also been developed to extend the shelf life of baked food, pulao, puranpoli, meat, fish products and health drinks by several months. User friendly technologies for the preservation of delicate fruits like litchi as well as processed food have also been developed and deployed.

Eco friendly packaging developed by BARC are also in extensive use in the food industry. A plant has been established for medium dose radiation processing of spices in Vashi, Navi Mumbai. A low dose radiation processing plant Krushak has been established at Lasalgaon near Nashik for processing of agro products. Radiation processing of Indian mangoes at Krushak has enabled the export of mangoes to USA. Now the technology has been extended to other fruits like pomegranates. This programme remains one of the proud contributions of BARC to the food security agenda of the nation.

## Radiation Processing for Food Preservation



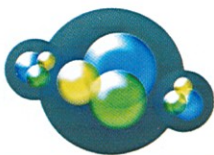
Radiation processing for food preservation



Use of gamma radiation to delay ripening of fruits and prevent sprouting of onions and potatoes



Applications of gamma radiation in preservation of various types of food products



## Isotope Hydrology

### Reviving Himalayan Springs

Water is a precious natural resource requiring efficient management and conservation. BARC has contributed significantly to the management and conservation of water resources by using the technique called Isotope Hydrology. Isotopes are variants of the same elements differing in atomic weights due to variation in the number of neutrons in the nucleus. In isotope hydrology, the ratios of isotopes of elements are measured and this information is used to devise strategies for water conservation in the affected areas. The hydrological investigation commences with collection of water samples from the water sources for the measurement of isotopic ratios.

Using isotope hydrology, the catchment areas of various Springs in mountainous regions are identified. The construction of suitable artificial structures is then carried out to increase the water flow. Confirming the presence of ancient buried water channels known as Paleo Channels, can be imaged by satellite thermal imaging. These channels can be revived and used for transporting the water from the Himalayan heights to distant places. Several ground water resources in India are affected by increasing salinity and contamination by fluoride, nitrate, arsenic, etc., Isotope hydrology has benefited large sections of the population and can be recorded as one of the important societal benefits occurring from the research activities of BARC.

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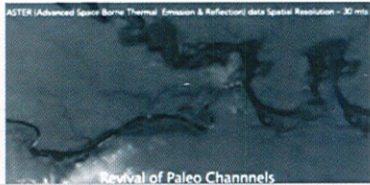
# Isotope Hydrology



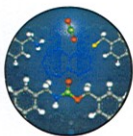
Water collection and hydrological study



Contaminated water sources



Applications of isotope Hydrology



## Radiotracers Applications

### Supporting the Industries

Bhabha Atomic Research Centre has made pioneering contributions in the use of radiotracers in industry for applications such as measurement of hydro dynamic parameters, flow visualization, process optimization and the evaluation of design of industrial process systems. In a radiotracer application, a radiotracer is injected into the system and its movement is monitored obstructively in selected locations along the systems using sensitive radiation detectors. This is an online measurement that is carried out without shutting down the plant. One of the most useful and widely

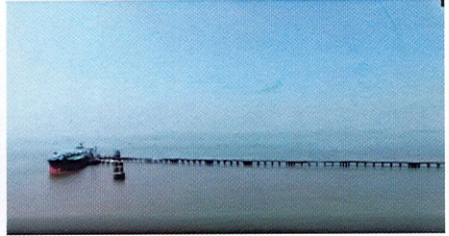


Applications of radiotracers in industrial sector

practiced applications is the detection of leaks in high- pressure heat exchangers, which saves about 15 to 20 days of plant shutdown time, leading to significant economic benefits for the end-user industry. Tracers are also used for measurement of flow rates in pipelines, canals, streams and mountainous rivers for calibration of flow meters and evaluation of efficacy of pumps. Measurement of the residence time distribution of processed fluid in industrial systems to ascertain causes of performance deterioration is also a useful application.

Dredging and dumping of sediments is carried out for maintaining the depth of the navigation channels in ports and harbors. The dredged and dumped sediments defined its way back to the channel defeating the cause of dredging or dumping. Radiotracers' studies have been carried to select suitable dumping sites at all the major ports in India during the last five decades. Radiotracers are used to optimize production costs in the oil industry. Radioactive particle tracking is used for studies in pilot scale chemical reactors for design evaluation and optimization prior to up scaling. Radio tracers are commonly used for estimating dilution and dispersion of the industrial effluents and domestic sewage discharge into water bodies to minimize contamination. A useful application is the identification of sea bed zones in water bodies such as dams, reservoirs and canals so that steps to mitigate sewage may be taken in a timely manner. The half-lives of the radio tracers and amounts used are very minute and posed no radiation hazards to the operator, public or environment. Radio tracer applications are carried out with the approval of concerned regulatory authorities and in compliance with all statutory requirements and therefore are safe, economical and unique techniques to solve many real time problems in various industries.

## Radiotracers Applications



Uses of radiotracers in navigation in harbours



Development of water sources by radiotracers



Indira Gandhi Centre for Atomic Research [IGCAR], the second largest establishment of the Department of Atomic Energy was set up in 1971 with the main objective of conducting broad based multidisciplinary programme of scientific research and advanced Engineering, directed towards the development of sodium cooled Fast Breeder Reactor [FBR] technology, in India.

**Indira Gandhi Centre for Atomic Research [IGCAR]**

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