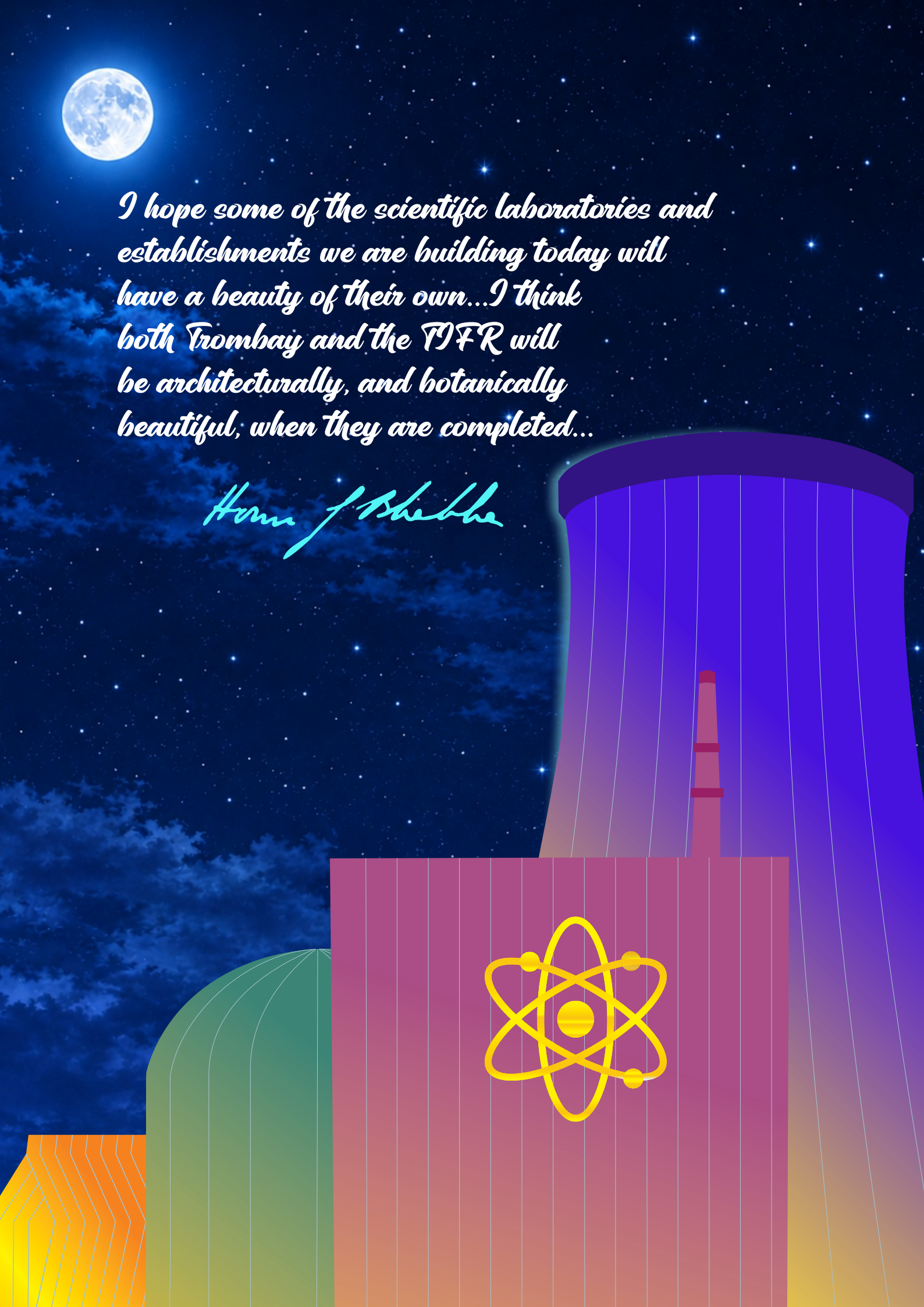

I hope some of the scientific laboratories and
establishments we are building today will
have a beauty of their own...I think
both Trombay and the TIFR will
be architecturally, and botanically
beautiful, when they are completed...

ADVANCING Radioisotopes

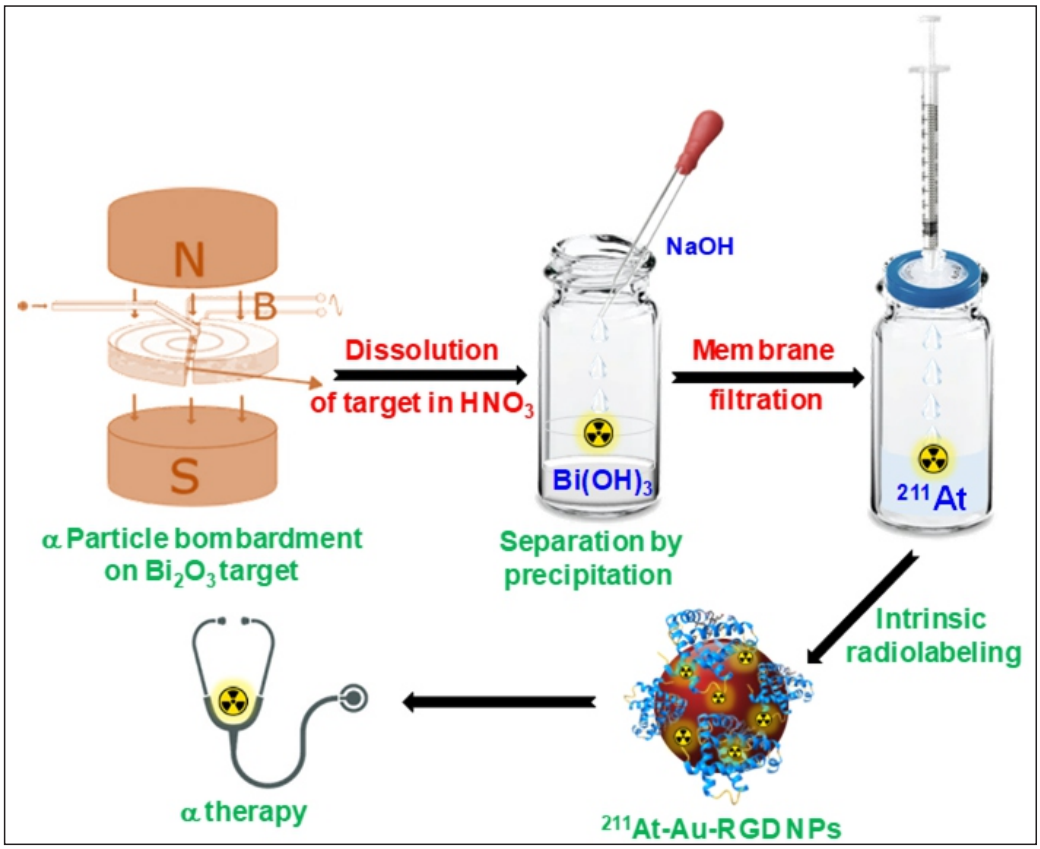
Robust Nuclear Medicine, Radiation Technologies & Water Management

प्रगत रेडियोआइसोटोप: सुदृढ़ परमाणु चिकित्सा, विकिरण तकनीकें और जल प्रबंधन

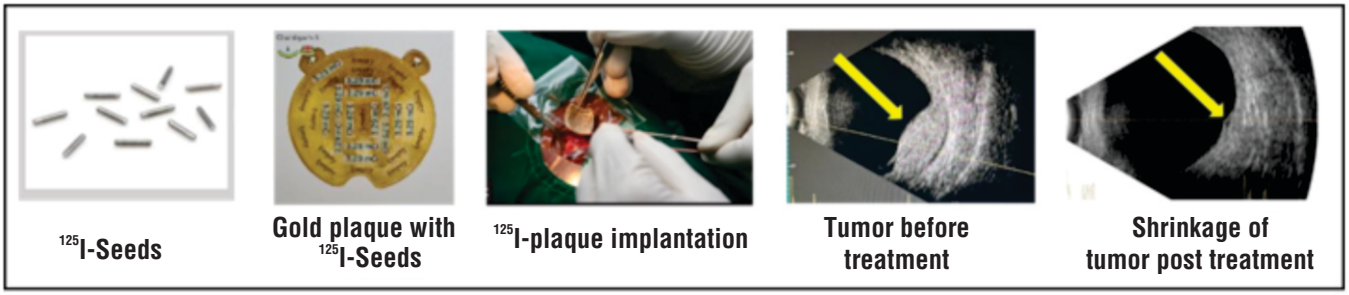
Indigenous Radioisotope Production for Healthcare: The Dhruva research reactor at BARC underpins India's indigenous radioisotope production programme, supporting diagnostic, therapeutic and theranostic applications through sustained production, radiochemical processing and stringent quality standards.

Lutetium-177 is a key radionuclide for targeted radionuclide therapy. Indigenous target materials and established production technologies enabled the production of approximately 1,400 Ci through 40 batches. This is helping cater to the growing demand for precision cancer therapy. Iodine-131 continues to support national clinical requirements, with over 330 Ci produced and distributed through numerous consignments. A new radioiodine processing facility at the CIRUS facility has been commissioned in accordance with regulatory requirements. Successful production of 50 Ci batches has demonstrated its capability; regulatory clearance for routine production and supply is awaited.

BARC also produces carrier-added Yttrium-90 and Samarium-153 for therapeutic



Production, radiochemical separation and purification of ^{211}At for targeted alpha therapy.



Implantation of 125 Iodine seeds in the patient and shrinkage of tumor post-treatment.

applications. Indigenous ^{90}Y glass microspheres (BhabhaSpheres) offer an affordable option for localized treatment of unresectable liver cancer, while Iodine-125 supports brachytherapy for ocular and prostate cancers. Together, these capabilities strengthen India's self-reliance in radioisotope production and provide a foundation for precision diagnosis, targeted therapy and theranostics.

Emerging Radionuclides for Precision Nuclear Medicine: BARC is developing indigenous production and radiochemical separation technologies for emerging radionuclides using DAE research reactors and accelerator facilities.

Using the Dhruva reactor, production routes have been developed for no-carrier-added (NCA) Holmium-166 and Terbium-161. NCA ^{166}Ho is produced from dysprosium through successive neutron-capture reactions, followed by selective radiochemical separation. Extraction chromatography and electrochemical methods enable efficient recovery and purification for radiopharmaceutical development. Parallel efforts aim to establish indigenous production of ^{161}Tb from gadolinium.

The BARC-TIFR Pelletron has enabled accelerator-based production of Manganese-52 and Iodine-124. NCA ^{52}Mn is produced by proton irradiation of chromium targets and purified electrochemically for PET imaging and nano-theranostic applications. ^{124}I is produced through the ^{124}Te(p,n)^{124}I reaction and purified using a mesoporous-alumina-based separation strategy. At VECC, Astatine-211 is produced by alpha irradiation of bismuth targets, followed by rapid precipitation-based separation to obtain NCA ^{211}At with high recovery and low target-derived impurities.

These developments integrate radionuclide production, purification and radiopharmaceutical applications, expanding indigenous capabilities for advanced PET imaging, targeted radionuclide therapy and targeted alpha therapy.

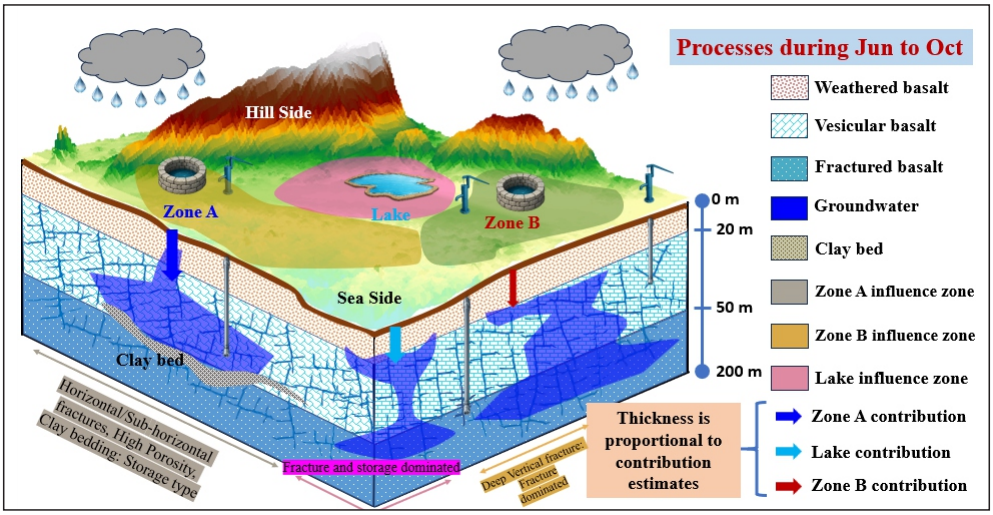
Ambient-Stable ^{99m}Tc-HYNIC-TOC Kits: ^{99m}Tc-HYNIC-TOC is a SPECT radiopharmaceutical used to diagnose and localize neuroendocrine tumours (NETs). Conventional freeze-dried kits require dry-ice transportation, increasing costs and complicating distribution.

BARC developed an ambient-temperature-stable freeze-dried formulation using mannitol as a bulking agent. Optimization of mannitol content, buffer volume and pH yielded a sterile, non-pyrogenic kit containing approximately 30 µg HYNIC-TOC, 40 µg stannous chloride dihydrate, 20 mg tricine, 10 mg EDDA, 26.3 mg sodium dihydrogen phosphate dihydrate, 5.6 mg disodium hydrogen phosphate dihydrate and 50 mg mannitol. The HYNIC-TOC ligand was synthesized in-house.

The formulation exhibited a uniform lyophilized cake, rapid reconstitution and stability for up to six weeks at ambient temperature, consistently producing radiolabelled material with high radiochemical purity. Following laboratory evaluation, kits were supplied to selected nuclear medicine centres for limited clinical evaluation. This development could reduce logistics costs,



Cathode ray assembly, Digital radiograph and Volume CT image.



Conceptual map showing potential rainwater harvesting areas in BARC Trombay Campus.

simplify distribution and improve access to NET imaging, particularly where cold-chain infrastructure is limited.

Isotope Hydrology for Sustainable Water Management: BARC employs stable and radioactive isotopes to assess groundwater recharge, surface-water interactions and sustainable water resource management.

In collaboration with Andhra Pradesh's Ground Water and Water Audit Department (GW&WAD), BARC is investigating the surface water - groundwater interactions along ~550 km Handri-Neeva Sujala Sravanthi canal system, which is expected to cater irrigation needs to ~6 lakh acres of farm land and provide drinking water to several hundreds of villages and mandals across drought-prone regions. Preliminary isotopic studies suggest canal-seepage up to 0.5 km. This three-year study will investigate over 50 sites along the canal system covering different seasons.



A 15 KLD pilot plant installed at the Heavy Water Plant at Vadodara.

An isotope hydrology investigation carried out as a part of R&D111 assessed the potential zones for groundwater recharge, aquifer interconnectivity and lake water - groundwater interactions within BARC premises, Trombay. The investigation was carried out in seven phases for three years and covered over 300 water samples for isotope-geochemical analysis and model development. The findings helped to propose effective measures for rainwater harvesting and revive defunct borewells as well as floodwater utilization. The outcome fosters self-sufficiency and sustainable water resources management.

Radiation Technology for Industrial Effluent Treatment: Following successful demonstration of a 75 KLD radiation-grafted cellulose-based adsorbent plant for cotton-textile effluent treatment, a 15 KLD pilot plant was installed at the Heavy Water Plant (HWP) Vadodara premises. Its four-cartridge system was demonstrated to HWP officials using simulated dye effluent, familiarizing them with operation and maintenance. Seven technology transfers have been completed to support commercialization, wider dissemination and market adoption.

Indigenous ^{177}Lu-Rituximab Kit for Radioimmunotherapy: Radioimmunotherapy combines antibody-mediated tumour targeting with radiation-induced cytotoxicity, offering a targeted approach to CD20-positive B-cell lymphomas.

BARC developed an indigenous freeze-dried kit for on-site preparation of ^{177}Lu-labelled rituximab. Rituximab was conjugated with the bifunctional chelator p-NCS-Bz-DTPA, and the immunoconjugate was purified using PD-10 columns. Each kit contained 3 mg purified rituximab-DTPA, 5 mg ascorbic acid at pH 5 as a stabilizer and 5 mg sucrose as a cryoprotectant. The formulation was optimized to preserve immunoconjugate integrity during lyophilization and support radiolabelling with activities up to 70 mCi of ^{177}Lu.

High radiolabelling efficiency and formulation robustness support decentralized preparation in clinical radiopharmacies. This technology offers potential to simplify logistics, improve accessibility and advance self-reliant, clinically scalable radioimmunotherapy for non-Hodgkin's lymphoma.

^{125}I Seeds for Ocular Brachytherapy: BARC's AERB-approved ^{125}I-OcuProsta Seeds (OPS1; classification C-43211) treat choroidal melanoma and other intraocular malignancies. With a half-life of 59.40 days, ^{125}I decays by electron capture, emitting X-rays and gamma radiation up to approximately 35 keV. Its localized radiation delivery helps spare adjacent healthy tissues and reduce recurrence risk.

Manufacturing involves loading 3-5 mCi of ^{125}I onto palladium-coated silver rods (0.5 mm diameter × 3 mm length), which are encapsulated in titanium holders (0.8 mm outer diameter × 4.75 mm length) using an Nd:YAG laser. Seeds are mounted on gold plaques that shield approximately 99.9% of outward radiation and direct the dose towards the tumour. Visual inspection, leachability, swipe and activity tests ensure compliance with AERB requirements.

Typically, 10-20 seeds are implanted, with activity and treatment duration adjusted to tumour size to deliver approximately 40-80 Gy over 5-8 days. Through BRIT, BARC supplied 27 seeds to P.D. Hinduja Hospital, Mumbai, and 20 to Government Medical College and Hospital, Chandigarh, during the past year.

Advanced Radiation Imaging for Non-Destructive Evaluation: BARC provides radiography and industrial computed tomography (CT) using 220 and 450 keV X-ray generators, a 7 MeV system and sealed sources including ^{192}Ir, ^{60}Co and ^{137}Cs, supporting research and non-destructive evaluation for BARC, DAE units, academia and universities.

A 225 keV X-ray facility with a flat-panel detector was used to examine a cathode ray assembly intended for accelerator applications. Digital radiography and multi-angle CT reconstruction revealed the locations, geometries and spatial distribution of internal features within the approximately 1 mm-thick metal casing. The findings support structural-integrity assessment and improved design.

Radiation Hygienization of Municipal Sewage Sludge: The Sludge Hygienisation Research Irradiator (SHRI) facility, Vadodara, continued safe, uninterrupted gamma irradiation of municipal sewage sludge. During the past year, approximately 654,000 litres of liquid sludge were treated, yielding around 39,000 kg of irradiated dry sludge. Vadodara Municipal Corporation expressed interest in integrating its upcoming 130 MLD sequencing batch reactor sewage treatment plant at Gajerawadi with the facility.

Collaborative studies also investigated radiation-induced damage to antimicrobial resistance genes in wastewater and sewage-sludge microorganisms. Initial experiments indicated complete damage to the targeted genes. Large-scale sludge hygienization plants at Ahmedabad Municipal Corporation (AMC) and Indore Municipal Corporation (IMC) continued operating, with additional source loading successfully completed.

Collectively, these initiatives demonstrate the application of indigenous nuclear science and radiation technologies to healthcare, industrial wastewater treatment, public sanitation and sustainable water-resource management.



BARC's RMRC Facility in Kolkata.

Advanced Diagnostic and Therapeutic Patient Services at RMC Mumbai: Established on September 3, 1963, by Dr. Homi Jehangir Bhabha, the Radiation Medicine Centre (RMC), Parel, Mumbai, provides Nuclear Medicine services and promotes radioisotope-based research. Its three core mandates are patient care, human resource development through postgraduate education, and basic and clinical research.

Over the past two and a half years, RMC has introduced five diagnostic studies and one therapeutic radiopharmaceutical for routine patient care and clinical research in oncology and neurological disorders.

^{68}Ga-DOTA-FAPI-04 PET-CT performed in over 300 patients, primarily for comparative disease staging in head and neck squamous cell carcinoma, metastatic medullary thyroid carcinoma, radioiodine-refractory thyroid carcinoma and TENIS. ^{68}Ga-Pentixafor PET-CT had been employed for over 50 patients with multiple myeloma, lymphoma and other haematolymphoid malignancies. It targets CXCR4, a receptor associated with several malignancies. ^{68}Ga-NODAGA-Exendin-04 PET-CT was used for over 40 patients with suspected or confirmed insulinoma. By targeting GLP-1 receptors, it facilitates sensitive detection of small tumours that may be difficult to localise anatomically. ^{68}Ga-NODAGA-RGD PET is under clinical investigation for radioiodine-refractory thyroid carcinoma, parathyroid adenoma and peripheral vascular disease. RGD peptides target $\alpha v\beta 3$ integrins associated with tumour neoangiogenesis. ^{99m}Tc-TRODAT SPECT had been used for evaluating Parkinson's disease and other movement disorders. ^{177}Lu-DOTA-FAPI-2286 therapy was initiated in June 2025 for metastatic medullary thyroid carcinoma and breast cancer.



Senior officers and support staff administer patient services at RMRC, Kolkata.

Fibroblast activation protein (FAP) is overexpressed in the tumour microenvironment of many epithelial cancers, with relatively low expression in most normal tissues. Its presence in pancreatic, colorectal, breast and ovarian cancers, sarcomas and medullary thyroid cancer makes it a promising target for ^{68}Ga-DOTA-FAPI-04 imaging and ^{177}Lu-DOTA-FAPI-2286 radioligand therapy.

Patient Services at RMRC Kolkata: Established and commissioned by RMC Mumbai under BARC, RMRC Kolkata is a modern Nuclear Medicine facility providing affordable diagnostic and therapeutic services, particularly to Eastern and Northeastern India.

Routine FDG-PET/CT services are established. ^{68}Ga-PSMA-11 PET-CT for prostate cancer and ^{68}Ga-DOTATATE PET-CT for neuroendocrine tumours commenced in July-August 2026. Regular I-131 therapy for thyroid cancer began in July 2025.

Therapeutic services include ^{177}Lu-PSMA-617 for metastatic castration-resistant prostate cancer, ^{177}Lu-DOTATATE for neuroendocrine tumours, and ^{131}I-mIBG for appropriate patients with metastatic neural crest tumours. Patient numbers continue to increase. RMC Mumbai and Tata Memorial Hospital's IT team are working to extend electronic medical record (EMR) facilities to RMRC Kolkata, strengthening inter-centre connectivity and access to treatment administration records.