SCIENCE AND INCLUSIVE DEVELOPMENT

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Mumbai

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What is Inclusive Growth?

- Focuses on pace and pattern of growth
- Creates economic opportunities along with ensuring equal access to all
- Productive livelihoods rather than direct income distribution
- Long term perspective (distinct from income distribution schemes which allow the poorer section to benefit from economic growth in the short run)
- Allows people to contribute to and benefit from economic growth
What need to Percolate to all sections of society?

- Good Governance
- Rapid and Sustainable Development of Infrastructure
- Education
- Energy
- Health care
- Food and Water
- Livelihood and Distributed Enterprise

Impact of Science and Technology Intervention
India’s Growth Story (a $1.3 Billion Economy with a population of 1.2 billion)

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>AVG GDP GROWTH/YEAR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st 30 years after independence</td>
<td>3.5</td>
</tr>
<tr>
<td>1980’s</td>
<td>5.6</td>
</tr>
<tr>
<td>1990’s</td>
<td>5.8</td>
</tr>
<tr>
<td>2005 to 2010</td>
<td>8.5</td>
</tr>
<tr>
<td>2011</td>
<td>9.0</td>
</tr>
<tr>
<td>2012</td>
<td>6.2</td>
</tr>
</tbody>
</table>
## Income Distribution in India

<table>
<thead>
<tr>
<th>Household income</th>
<th>Household income</th>
<th>Population</th>
<th>Disposable Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD 1990 PPP</td>
<td>USD 2010 nominal</td>
<td>Millions</td>
<td>Billion USD 2010 nominal</td>
</tr>
<tr>
<td>&gt;$8</td>
<td>&gt;$17.03</td>
<td>25</td>
<td>294</td>
</tr>
<tr>
<td>$4 - $8</td>
<td>$8.52 - $17.03</td>
<td>85</td>
<td>241</td>
</tr>
<tr>
<td>$2 - $4</td>
<td>$4.26 - $8.52</td>
<td>246</td>
<td>320</td>
</tr>
<tr>
<td>$1.25 - $2</td>
<td>$2.45 - $4.26</td>
<td>415</td>
<td>257</td>
</tr>
<tr>
<td>&lt;$1.25</td>
<td>&lt;$2.45</td>
<td>419</td>
<td>101</td>
</tr>
</tbody>
</table>

**SOURCE:** McKinsey Global Institute; Global Insight; EIU

### Emergence of middle class

- **Rich Above Rs. 17 Lakhs**
- **Middle Class Rs. 3.7 - 17 Lakhs**
- **Aspirers Rs. 1.5 - 3.4 Lakhs**
- **Deprived Below Rs. 1.5 Lakhs**

### Graph Comparison

**1970 vs 2000**

- **Income per year**
- **Number of people**
Discovery - Innovation - Deployment Cycle

Science and Engineering

Creating Ideas

Select / Combine ideas

Innovations
Creating Products

Push from developers and pull from market

Deployment & Distribution
Delivery to users

Continuous upgradation to face competition
USA based IEEE has proved what has been a century old suspicion amongst academics that the pioneer of wireless-radio communication was Professor Jagdish Chandra Bose and not Guglielmo Marconi
- Demonstrated in 1895 remote signaling by wireless some two years before Marconi's famous Salisbury Plain demonstration of 1897.

- **Groundbreaking** measurements of the effect of electromagnetic radiation on plant growth.

- Research into electromagnetic waves, use and development of innovative microwave components and the first use of semiconductors Bose was clearly some 50 years ahead of his time.

- Discovered that atmosphere was responsible for blocking short wavelength radio wave

(Source : National Radio Astronomy Observatory, NSF, USA)
Incremental Development versus Revolutionary Change

**Printing**

- Mechanical Typewriter
- Golf Ball
- Daisy Wheel
- Dot Matrix
- Ink jet
- Laser
- Desktop Publishing

**Communication**

- Wired - Telegraph
- Telephone
- Telex – Wi-Fi
- Fax
- Email – Satellite
- Voice / Data / Image transfer
SCIENCE & TECHNOLOGY: CAN THEY BE CATALYSTS FOR INCLUSIVE GROWTH

Creation & Adoption of New Scientific Techniques and Implementation of Technology in societal sectors are key to National Prosperity
FOUNDING FATHER'S CONCEPT

Before you do anything, stop and recall the face of the poorest, most helpless destitute person you have seen and ask yourself, “Is what I am about to do going to help him?”

– Mahatma Gandhi
Role of Science & Technology in economic development

Innovation
- Leadership in usable knowledge
- Competition driven

Knowledge Seekers
- Creation of jobs
- Creation of knowledge
- National prosperity

Technology
- Market driven
- Gainful and useful knowledge

Science
- Scholarship driven
- Advanced knowledge

T Ramasamy, STI Policy, 2013
“The key to national prosperity, apart from the spirit of the people, lies in the modern age, in the effective combination of three factors i.e. technology, raw material and capital, of which the first is perhaps the most important.

The creation & adoption of new scientific techniques can, in fact, make up for a deficiency of natural resources and reduce the demand on capital. But, technology can only grow out of a study of science and its applications.”
A GLOBAL MACRO ECONOMIC SURVEY

Science & Technology Driving Socio Economic growth

- India, China, Brazil
- Europe, USA & Japan
- Afro-Asian Countries
- Oil Rich Middle East

Normalised Economic Strength

Science & Technology Index
Changing Contexts of Social Challenges of India

**Between 1950-90 era**
- **Ground realities:**
  - Food shortage
  - Wide spread poverty
  - Social inequities
  - Low rates of employment
  - Unfavorable trade balance
  - Lack of technology culture
  - Weak infrastructure

- **Science delivered solutions for:**
  - Food and milk shortages
  - Technology denials in strategic sectors
  - Communication & Infrastructure

**Between 1990-2030 era**
- **Social challenges seeking science derived solutions:**
  - Energy, Environment & Climate change
  - Water
  - Increased food production
  - Education
  - Affordable health care

Competitive world economy and trade impact the fundamentals of scientific solutions

Flow of Solution science is global and wide reaching
Challenges faced by Indian Science, Technology and Innovation system

- **Mission mode Agencies**: Focused on self reliance, under transition in the era of techno-globalisation
- **Government R&D Bodies**:  
  - balancing the art of funding between solution driven science / technology and curiosity driven science  
  - development of market driven technology and competition linked innovation system
- **Academic sector**: Challenged by need to expand many fold in education without dilutions of excellence and loss of focus on research
- **Socio economic ministries seeking solutions from science**: Challenged by mis-matched rates of scientific development and societal absorption of global solutions
- **Industrial Research**: Competition between in-house development and technology imports
Science intervention in Agriculture: Excellent example of inclusive Growth

- Green Revolution resulted production of 131 Million tonne of food 1978-79
- Yield per unit of farm land improved by 30 % between 1947-79
- Crop area under high yield varieties grew from 7% to 22%
  - 70% of wheat, 35% of rice, 20 % millet and corn, crop areas used HYV seeds.
- New dams created for increased irrigation also generated hydro electric power - created jobs, improved quality of life of people in villages
- Growth also occurred in agriculture based industry like fertilizers, chemicals and machineries
- India paid back all world bank loan - improved creditworthiness
- Indian farmers invited to other countries for demonstrating green revolution elsewhere.
Today India is the largest producer of milk in the world.

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (Million Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-91</td>
<td>53.9</td>
</tr>
<tr>
<td>2006-07</td>
<td>102.6</td>
</tr>
<tr>
<td>2009-10</td>
<td>116.42</td>
</tr>
<tr>
<td>2010-11</td>
<td>121.8</td>
</tr>
</tbody>
</table>

Per capita availability (269 grams/day) is still lower than the world average (286 grams/day).

The growth path of milk production in India
Space Technology Revolutionized Communication and Information

- Telephone transmission
- TV broadcasting
- Electronic mail
- Global positioning system (GPS)
- Radio program
- Remote sensing
Inclusive Growth and Appropriate Technology

Innovations by local artisans and craftsmen can lead to appropriate technology development.

Frugal

Flexible

Jugaad

inclusive
APPLICATIONS OF RADIATION TECHNOLOGY IN AGRICULTURE

➢ GENETIC IMPROVEMENT OF CROP PLANTS
➢ PRESERVATION OF AGRICULTURAL PRODUCE
Effect of Radiation on DNA - Mutation Breeding

- MUTATION BREEDING
- CROSS BREEDING
- DNA RECOMBINANT TECHNOLOGY

• Mutations occur spontaneously in nature ($10^{-7}$ to $10^{-4}$)
• Artificial Mutations by physical and chemical agents/mutagens at higher frequency ($10^{-2}$ to $10^{-3}$)
Mutations result in a large germplasm with varying characters such as:

- Altered seed size or colour or oil composition
- Enhanced yield
- Tolerance to diseases/drought, salinity etc
- Altered plant height
- Early maturity

Breeder can combine these characters to develop new crop varieties
Using radiation induced mutations, 41 crop varieties have been developed and released so far for commercial cultivation in different agro-climatic zones in the country. Some of the varieties are very popular and grown extensively. The improved characters are higher yield, earliness, large seed size, resistance to biotic and abiotic stresses.
Towards societal benefits...

LAB TO LAND........to......LAND
Development and deployment through linkages

Indian Council Agricultural Research
State Agricultural Universities
National /State Seed Corporations
Krishi Vigyan Kendras, Seed villages
NGO, Progressive Farmers

STRAND
Stimulation of Tribal and Rural Neighborhood Development

Kissan Mela Exhibitions
Awareness programmes

Akruti
IAEA

Inter-Departmental interactions
DAE and Ministry of Agriculture

Together We Win

Farmers Federation

Awareness programmes
Trombay Groundnuts & A.P. Farmer
Trombay groundnuts in different states....
Large seed size in Groundnut

Large seed size with early maturity (110-120 days) Large seed size has applications in Confectionery and export and are rapidly gaining popularity among the farmers in India. Some economically important include TKG-19A, TPG-41, TLG-45, TBG-39/TDG-39
## Proposed Qty & Estimated value of Production of Certified Seed Program for Oilseeds & Maize during 2012-13

### National Seeds Corporation Ltd

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Crop / Variety (NSC)</th>
<th>Year of Release</th>
<th>Production (Qtls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TAG-24</td>
<td>1992</td>
<td>35000.00</td>
</tr>
<tr>
<td>2</td>
<td>TG-37 A</td>
<td>2004</td>
<td>7000.00</td>
</tr>
<tr>
<td>3</td>
<td>TPG-41</td>
<td>2004</td>
<td>9000.00</td>
</tr>
<tr>
<td>4</td>
<td>GPBD-4 (Vikas)</td>
<td>2004</td>
<td>13000.00</td>
</tr>
<tr>
<td>5</td>
<td>Kadiri -6 (K-6)</td>
<td>2005</td>
<td>61000.00</td>
</tr>
<tr>
<td>6</td>
<td>TG-38</td>
<td>2006</td>
<td>10000.00</td>
</tr>
<tr>
<td>7</td>
<td>ICGV-91114</td>
<td>2007</td>
<td>7000.00</td>
</tr>
<tr>
<td>8</td>
<td>Kadiri-9</td>
<td>2008</td>
<td>9000.00</td>
</tr>
<tr>
<td>9</td>
<td>TG-51</td>
<td>2008</td>
<td>6000.00</td>
</tr>
</tbody>
</table>

**Groundnut Total**

157000.00

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67000 Qtls / 157000 Qtls

42%

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No.7-3/2012-AAP/TMOP
Government of India
Ministry of Agriculture
Department of Agriculture & Cooperation

Krishi Bhawan, New Delhi
Dated: 5th September, 2012
Trombay Pulses under Rice Fallow cultivation in AP
Special Niche- Rice Fallows

Mungbean: TM-96-2

Urdbean: TU-40

Mungbean: TM-2000-2 (Paicy mung)

Crop amidst rice stubbles
Protocols for large scale production of commercially important varieties of banana, pineapple and sugarcane have been developed.

Technology for the tissue culture production of banana has been transferred to MSSC, Akola, Maharashtra and Krishi Vigyan Kendra, Govt. of Pondicherry, Pondicherry. 

Sunshine Agri (Jalgaon)

The promising clones of sugarcane derived from tissue culture are being evaluated at Marathwada Agricultural University Parbhani.
Dissemination of Trombay Crop Varieties
# Radiation Processing of Food

<table>
<thead>
<tr>
<th>Radiation Processing of Food</th>
<th>Low-dose Applications (&lt; 1 kGy)</th>
<th>Medium dose Applications (2-10 kGy)</th>
<th>High dose Application (&gt; 10 kGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiological Improvement</td>
<td>Disinfestation</td>
<td>Pasteurization</td>
<td>Sterilization</td>
</tr>
<tr>
<td>Fruits &amp; vegetables</td>
<td>• Destroys storage insects</td>
<td>• Destroys spoilage and disease causing microbes</td>
<td>• Destroys all microbes</td>
</tr>
<tr>
<td>• Control sprouting</td>
<td></td>
<td>• Requires irradiation at low temperatures</td>
<td></td>
</tr>
<tr>
<td>• Delay of ripening &amp; senescence</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Low-dose Application (< 1 kGy)

**Quarantine treatment of export / import commodities**

To destroy quarantine insects and microbes, overcome quarantine barriers, get international market access
Major National Developments

1986  Setting up of National Monitoring Agency by GoI
1991  Atomic Energy (Control of Irradiation of Food) Rules notified
1994  Prevention of Food Adulteration (Fifth Amendment) Rules (Additional approvals in 1998 & 2001) (Now Food Standards & Safety Authority of India)
2000  Setting of Radiation Processing Plant, Vashi, for hygienization of spices
2003  MoA amended Quarantine regulations to include irradiation as a quarantine measure
2003  Setting of KRUSHAK* Irradiation Facility, Lasalgaon, for preservation of agro commodities
2006  FWEP** Signed by MoA with USDA-APHIS*** for export of mango
2007  KRUSHAK facility approved by USDA-APHIS for quarantine treatment and export of mango started
2012  Atomic Energy (Radiation Processing of Food & Allied Products) Rules notified (generic food class-wise approval)

* Krushi Utpadan Sanrakshan Kendra
** Frame work equivalence work plan
***United States Department of Agriculture- Animal & Plant Health Inspection Service
Radiation Processing of Spices

- India is the largest producer and consumer of spices
- Spices contain high microbial load that may cause food borne illnesses
- Insect infestation during storage is a major cause of loss in spices
- Irradiation is a good alternative to fumigants
- R&D carried out during 1984-1989
- First technology demonstration plant, Vashi, Navi Mumbai (32 Tons/d; 2000 Tons/ Year)
- Commercial irradiation started in 2000
KRUSHAK Irradiation Facility, Lasalgaon

- Second technology demonstration facility for low dose applications
- Sprout control in onion, garlic, potato
- Disinfestation of cereals, pulses and their products
- Quarantine treatment of mango
- R&D carried out in 1970-80’s; KRUSHAK became operational in 2003
- 10 Tons/ h (Potato) 4 Tons/ h (Mango)

Export of mango to USA
2007: 157 Tons
2008: 275 Tons
2009: 130 Tons
2010: 100 Tons
2011: 95 Tons
2012: 275 Tons
Shelf life Extension of Litchi

- Litchi is highly perishable fruit, skin starts browning after harvest
- Using a sequential dip treatment in simple safe chemicals, shelf life extension by > 45 d
- For export can be combined with irradiation at 400 Gy as quarantine treatment
- Technology transferred to traders and farmers
# Food Irradiation Facilities in India

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Facility</th>
<th>Loading (kCi)</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISOMED (BRIT), Mumbai</td>
<td>350</td>
<td>Medical products, spices, dry ingredients (EU approved)</td>
</tr>
<tr>
<td>2</td>
<td>SARC, SIIR, Delhi</td>
<td>500</td>
<td>do</td>
</tr>
<tr>
<td>3</td>
<td>Radiation Processing Plant, Vashi, Navi Mumbai</td>
<td>400</td>
<td>Spices, dry Ingredients (EU approved)</td>
</tr>
<tr>
<td>4</td>
<td>VIKIRAN, M/s Organic Green Foods Ltd., Kolkata</td>
<td>280</td>
<td>do</td>
</tr>
<tr>
<td>5</td>
<td>STERICO, AV Processors Pvt., Ltd., Mumbai</td>
<td>350</td>
<td>do</td>
</tr>
<tr>
<td>6</td>
<td>Universal ISOMED, M/s Universal Medicap Ltd.,Vadodra</td>
<td>540</td>
<td>do</td>
</tr>
<tr>
<td>7</td>
<td>M/s Microtrol Sterilization Services Pvt. Ltd., Bangalore</td>
<td>500</td>
<td>do (EU approved)</td>
</tr>
<tr>
<td>8</td>
<td>KRUSHAK, BRIT/BARC</td>
<td>275</td>
<td>Mango, dry ingredients</td>
</tr>
<tr>
<td>9</td>
<td>M/s Gamma Agro Medical Processing Pvt. Ltd., Hyderabad</td>
<td>75</td>
<td>Spices, medical products</td>
</tr>
<tr>
<td>10</td>
<td>M/s Agrosurg Irradiators Pvt. Ltd., Mumbai</td>
<td>250</td>
<td>Spices, dry Ingredients</td>
</tr>
<tr>
<td>11</td>
<td>M/s Jhunsons Chemicals Pvt. Ltd., Bhiwadi</td>
<td>300</td>
<td>Rice, spices, dry ingredients</td>
</tr>
<tr>
<td>12</td>
<td>M/s Innova Agri Bio Park Ltd., Bangalore</td>
<td>300</td>
<td>Agricultural commodities</td>
</tr>
<tr>
<td>13</td>
<td>M/s Hindustan Agro Co-operative Ltd., Rahuri</td>
<td>100</td>
<td>do</td>
</tr>
</tbody>
</table>
Urban & Rural Waste Management

- 20,000 cu.m of sewage sludge treated and 800 tonnes of pathogen free manure produced (2007)
- Sludge has been tested as manure in agriculture fields
- Plan to set up several sewage treatment plants under J N National Urban Renewal Mission

The hygienized sludge is an ideal medium to grow nitrogen fixing bacteria like Rhizobium and hence can be converted easily into a bio-fertilizer.

<table>
<thead>
<tr>
<th></th>
<th>Un-irradiated (counts/ml)</th>
<th>Irradiated (counts/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Bacteria</td>
<td>2x10^6</td>
<td>8x10^2</td>
</tr>
<tr>
<td>Fecal coliform</td>
<td>1x10^5</td>
<td>38</td>
</tr>
<tr>
<td>Rhizobium</td>
<td>4x10^7</td>
<td>9x10^9</td>
</tr>
</tbody>
</table>
Isotope Techniques for Water Recharging

- Identification of recharge areas
- Establishment of flow paths
- Aquifer identification

Gaucher, Uttarakhand, India

Environmental Isotopes:

\[ ^2H, ^{18}O, ^{13}C, ^{14}C, ^{36}Cl, ^3He \]

Cosmic radiation products

\[ ^{14}N_7 + \, ^1n_0 \rightarrow \, ^3H_1 + ^{12}C_6 \]

\[ ^{14}N_7 + \, ^1n_0 \rightarrow \, ^1H_1 + ^{14}C_6 \]

\[ T_{1/2}(^{3}H_1) : 12.43 \text{ years} \; ; \; T_{1/2}(^{14}C_6) : 5734 \text{ years} \]
Artificial recharge structures at identified locations

Techniques applied:

- Measurement of physical parameters like pH, temperature and electrical conductivity.
- Analysis of major cations and anions.
- Measurement of environmental stable isotopic ratios of $^{18}$O/$^{16}$O, $^2$H/$^1$H and environmental tritium.
- Geomorphologic and hydrogeological data.

Subsurface dykes, check bunds and a few contour trenches were constructed for rainwater harvesting.
Out of 17 springs, the discharge rate of 9 springs has increased three to nine times and also two new springs have appeared. Almost all the springs have become perennial and 3 villages [About 10,000 people] are getting enough water through out the year.
Transforming Dry to Cultivable Areas
Western Ghats, Maharashtra State

Issue: In Amaravati district, very low groundwater potential and also of saline nature → farmers drill boreholes up to 100-150m, most wells fail → struggle for fresh water in the region → drastic decline in groundwater levels due to large scale exploitation.

Findings & Outcome: about 10 km south of Chinchona hill range, a huge groundwater sanctuary identified (and also confirmed by geophysical survey) → local authority drill bore hole of 60m depth at identified site → yield ~30,000 L/h, a perennial source of good quality water supply to 5-6 villages [for about 30,000 people] for drinking and irrigation.
Amaravati before Intervention

Amaravati after Intervention

BARC Isotope Hydrology Team
Ongoing Activities

Spring Recharge:
Similar studies are in progress involving about 125 springs at 11 more locations across 5 states in India; 4 in Uttarakhand, 2 in Himachal Pradesh, 2 in Jammu & Kashmir, 1 in Mizoram and 2 in Maharashtra.

Aquifer Identification in Water Scarce areas:
6 locations in Western Maharashtra

Propagation of technology:
Through NGOs, by establishment of isotope hydrology laboratory at Dehradun, Uttarakhand.
Nuclear Desalination

Energy input: Low Pressure Steam

Key Features
- Large capacity plants
- Distilled quality product

Multi-Stage Flash (MSF) Desalination
Nuclear Desalination Demonstration Plant (NDDP) Kalpakkam (India)

- Largest Nuclear Desalination plant based on hybrid technology

- Capacity: 6.3 Million Litres/Day (MLD)
  - MSF: 4.5 MLD
  - RO: 1.8 MLD

Provided training to the interested Member States (such as Algeria and Syria) in nuclear desalination through IAEA Technical Cooperation Program.

NDDP sharing LP steam, electricity and seawater with MAPS
Nuclear Desalination Demonstration Plant (NDDP) Kalpakkam India (Reverse Osmosis Section)

MSF (4.5 MLD) is supplemented with (RO) section (1.8 MLD)

- Consistent product quality
- Longer membrane life
- Higher membrane flux
- Energy cost: 0.35 cents/10L desalinated water produced
Nuclear Desalination

Energy input: Low Pressure Steam

Key Features:
- Medium capacity plants
- Compact
- Distilled quality product

Schematic Diagram of Multi-Effect Distillation (MED)
Seawater Desalination using Waste Heat from Nuclear Research Reactor at Trombay (India)

Key Features:
• Capacity: 30 Kilo Litres/ Day (KLD)
• Energy input: Waste heat as hot water (1 MWth)
• No chemical requirement
• Product quality: Better than DM water

It is planned to integrate a desalination plant with AHWR using its low grade heat for sea water desalination.
Community size water purification systems (0.1–100 KLD capacity)

Pressure Driven Membrane Processes

- **MicroFiltration (MF)**
  - Pressure Drop: 10-300 kPa
  - Particles, Parasites, Bacteria, Viruses
  - 100-2000 A

- **UltraFiltration (UF)**
  - Pressure Drop: 50-500 kPa
  - Mid-size organics, multiple charged ions
  - 20-100 A

- **NanoFiltration (NF)**
  - Pressure Drop: 0.5-1.5 MPa
  - Low molecular substances, single charged ions
  - 10-20 A

- **Reverse Osmosis (RO)**
  - Pressure Drop: 0.5-1.5 MPa
  - 5-10 A

Diagram showing different membrane processes and their pressure drops and filtrated substances.
Membranes Developed in BARC

I. Cellulose acetate asymmetric membranes for brackish water RO

II. Polysulphone (PS) / Polyethersulphone (PES) for UF

III. Polyamide TFC Membranes for brackish water RO & seawater RO

IV. Polysulphonamide membranes for NF

Plate and Frame RO Element

Tubular RO Element

Spiral UF & RO Elements
Iron, Arsenic, Fluoride removal from water

physico-chemical process assisted by membrane technology - transferred to private parties for wider deployment.

Small community model (600 LPD* capacity)

Maharashtra

Community (5 KLD** capacity)

LPD*: Litres Per Day    KLD**: Kilo-Litres Per Day
Brackish Water Desalination-Salinity Removal from Ground Water

Brackish Water Reverse Osmosis (RO) Plant in Villages for producing Drinking Water
(Energy Requirement 1 kwh/m3 (approx))
Community size desalination units (KLD or m3/day capacity)-**Patent Nos. 194106; 195317**

- Technology transferred to private parties for wider deployment
- commercially viable

Sheelgaon village, Barmer, Rajasthan (30 KLD capacity)

Satlana village, Jodhpur, Rajasthan (30 KLD capacity)

Pharare Fisherman Hamlet Ratanagiri District (7.2 KLD capacity)
Technology for Remote/ Rural Areas without Power Supply

Solar PV Based Brackish Water RO Plants
(200 Liters Per Hour (LPH) capacity)

Bi-cycle mounted Water Purification Unit
(80 LPH UF/ 10 LPH RO)
Nisargruna plants

4 MT/day

Methane produced used as fuel in kitchen or in a boiler for generating steam and producing power

- 160 Plants in operation
- ~ 100 more in pipeline

1MT/day

SYMBIOSIS, PUNE

5MT/day

ANKALESHWAR, GUJRAT
Advanced Knowledge and RUral Technology Implementation (AKRUTI)

Nisargruna
Foldable solar dryer
Vibro thermal disinfestor
Domestic water purifier
Food processing units
Soil organic carbon detection kit

AKRUTI at Chiplun, Maharashtra
Healthcare Equipment

Bhabhatron – indigenous telecobalt machine

23 machines are in operation

Many more in pipeline

Tele ECG machine

Technology transferred for commercial production

Features

• Low cost, portable and compact
• Mobile as well as LAN connectivity
• Acquisition, processing, storing and visualization of ECG in real time
• Using a secure GPRS connection for transfer of ECG data
Cancer Burden In India

- 30-40 lakh cases
- 10.5 lakh new cases
- 7 lakh deaths/ year

Cancers You Get From Smoking

- Pancreas (4%)
- Esophagus (5%)
- Larynx (2%)
- Lung (78%)
- Mouth (3%)
- Stomach (2%)
- Leukemia (1%)
- Bladder (3%)
- Kidney (2%)
- Cervix (1%)

Most Common Cancers

- Tobacco related: 30% of all new cases
- Cancer of the cervix uteri: 30% of new cases in women
- Cancer of the breast: 20% of all new cases in women

Cancer incidence is expected to be doubled in next 15 years
Indigenous Tele-therapy Machine

Radiation therapy machine for the treatment of cancer patients.
Delivers planned amount of radiation dose to the designated target safely and accurately.
Computer controlled machine uses Cobalt-60 source.
Matches international standard at nearly half the cost.
23 operating machines many of them in rural and semi-urban areas

Diagnostic X-ray in place of high-energy therapy beams

Simulator for treatment planning.
Bhabhatron Development

The first patient being treated in Bhabhatron-I at ACTREC (2005)

President, Dr APJ Abdul Kalam Inaugurated Bhabhatron-II (2006)

IAEA Director General, Dr El Baradei visited ACTREC (2007)

Bhabhatron installed in Vietnam based on PACT, IAEA (May 2010)

Agreement signed at IAEA for donation of one Bhabhatron-II to Sri Lanka (Sep 2010)
I-125 sources for brachytherapy of Ocular Cancers

- 0.5mm (ϕ) x 3mm (l) silver rods are coated with I-125 (typically 111MBq/3 mCi/seed), encapsulated in 0.8mm (ϕ) x 5 mm (l) titanium capsules of 50 micron thickness by laser welding.

- Several (15-25) such seeds are glued to a gold plaque custom-made to suit the size of the patients eye.

- The plaque is sewn into the eye to deliver 40-60 Gray of radiation dose and then removed (typically 8-12 days).
Radiopharmaceuticals Currently In Vogue

I-131 : For Thyroid disorder diagnosis and treatment

P-32 : For reducing pain of cancer in bone marrow

I-131 Labelled compounds : For cancer treatment of various organs

Ho-166 labeled to Hydroxy Apatite : to relieve pain and inflammation in arthritis patients

P-32 labeled to Samarium colloid : being developed for treatment of Joints.
Flat Panel Detector based Advanced Digital Medical Imaging System

Amorphous Silicon based FPD with CsI 17”x17”

X-Ray Generator 65 KW/200 MHz

Latest Microprocessor controlled patient table

Digital Image acquisition, processing and archiving.

Radiography and fluoroscopy in one

Hand phantom - fluoroscopy  Chest -lung phantom – fluoroscopy  Chest -lung phantom – radiography  Region of interest zooming– Micro - radiography
**X-ray Phase contrast Imaging Technique Imaging using coherent X-rays**

Developed for reactor fuel NDT finds application in Biomedical & Material Science applications.

\[ I = I_0 \exp(-\mu x) \]

In phase contrast imaging the intensity \( I \) is given by

\[ I \propto \nabla^2 \phi \text{ or } I \approx \nabla \phi \]

\( \phi = \text{phase of the object} \)

**Conventional Image Forming Method**

- Absorption Contrast: Density difference due to absorption by the object.
- New Image Forming Method:
  - Phase Contrast: Density difference due to refraction by the object.

\*This new method keeps the object apart from the detector.

**Sources:**
- Synchrotron - (full coherence)
- Mammography - Soft tissue imaging
- Cancer research - Biological Specimens

**Zoomed Image**

**Zoomed Area**

**Image Surface**

- Dense
- Sparse
- Dense

**Image Density**

- Black
- Gray
- White

**TRISO particle (Zirconia Kernel) UO\(_2\)**

**Phase image**

**Insect**

**SiC**

**PyC**
Potential Biomedical Applications of Phase Contrast Imaging

Synchrotron Radiation Imaging of Breast Tissue
Development of X-ray Imaging beamline at INDUS-II, RRCAT

FEATURES OF IMAGING BEAMLNE

Monochromatic beam Mode

White beam Mode
- Real time experiments
Today India has —

• 1.5 Gigabit dedicated fiber link to CERN,
• Two 2.5 Gigabit TEIN3 links – one to Europe and other to Singapore through Trans-Eurosia Information Network TEIN 3 program
• One Gigabit link to Institute via NKN
NKN APPLICATIONS

NKN e-Classroom

High Energy Physics

NKN Webcasting

Climate Change

Remote Experiment

Engineering Research Collaboration: Complex Systems from Nuclear to orthodontics (Collab CAD platform)
National Knowledge Network
Creation of Virtual Classrooms (VCR)

66 Virtual Classrooms (VCR) being created
(38 VCR at IITs, 23 VCRs at NITs, IISc, IIESR & 5 VCRs at NIC)
Large Hadron Collider (LHC)

- Installed in a tunnel of ~ 27 km circumference ~ 100 m below the ground passing through two countries Switzerland and France
- Constructed in worldwide collaborations
- Started colliding 3.5 TeV protons in 2010
- LHC experiments will produce 10-15 million Petabytes of data each year (about 20 million CDs!)
India is actively collaborating with Europe in several domains and, noticeably in scientific research. For collaborating in scientific research - e-Infrastructures is of paramount importance.

However, an intense research activity will be continued and expanded if researchers are able to access remotely, expensive scientific instruments, laboratories, applications, data/images and collaborate with finest minds of leading edge researchers.

Cooperation with Global Virtual Research Communities (GVRCs) through high impact projects like LHC Grid & EU-IndiaGrid gave India much needed impetus for creating an e-infrastructure within India.
Virtual Lab via NKN

HBNI, Mumbai

ESRF (FIP), Grenoble, France

X-Ray Diffraction Pattern

Atomic level Structure

Organic Synthesis

A Laboratory without walls

Libraries

1 Gbps NKN

2.5 Gbps TEIN3 link Geant
Distributed Manufacturing Through NKN

- Collaborative design and development
- Data transfer from designer to manufacturer
- Control of robotized manufacturing units
  - Rapid prototyping, laser engineered net shape processing
  - Remote assembly line control
  - Quality check
- Manufacturing distributed to different locations having necessary machinery and infrastructure

NKN (with features: low latency (micro sec), high bandwidth (1 Gb/s) and high security) enables sophisticated and cost effective manufacturing at remote locations with limited manpower.
Energy : Air Pollution dirty Fuels in Rural India

- 96% of households use biomass energy, 11% use kerosene and 5% use LPG for cooking. Most of them use multiple fuels.
- Forests contribute 39% of the fuel wood need.
- 314 Mt of bio-fuels are gathered annually.
- 85 million households spend 30 billion hrs. annually in fuel wood gathering.
Burden of Dirty Fuels

• Respiratory symptoms are prevalent among 24 million adults of which 17 million have serious symptoms

• Adults suffering
  – 16% from Bronchitis
  – 5% from Bronchial asthma
  – 8.2% from Pulmonary TB and
  – 7% from Chest infection

• Risk of contracting respiratory diseases and eye diseases increases with longer duration of bio-fuels
HUMAN DEVELOPMENT INDEX AND ELECTRICITY CONSUMPTION

This perhaps would be the optimum point we should aim at.

Source: Dr. Steve Chu, Department of Energy, US
Nuclear Power for Sustainable Supply of Energy - Indian Scenario

Installed capacity (GWe)

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>~4.7 billion tonne/year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>~7.7 Gte of CO$_2$ emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Per Capita Consumption:
- 5000 KWh/year (Human Dev. Index: 0.8-0.85)
- 600 KWh/year

Deficit: 1100 GWe

- 9% Growth Rate [1]
- 8% Growth Rate [1]
- DAE [2]
- Renewable including hydro [2]

Nuclear share must increase multifold to meet energy demands

References:
Nuclear power is good for the climate

Nuclear power: Very low lifecycle GHG emissions make the technology a potent climate change mitigation option.

Nuclear power: Very low lifecycle GHG emissions make the technology a potent climate change mitigation option.
Nuclear Capacity Buildup

- **Present Capacity**: 4780 MW

- **By 2017 on completion of reactors under construction (5300 MW)**: 10080 MW

- **On completion of new launches planned in XII Plan by 2023-24**: 27480 MW

- **By 2032**: 63000 MW
  (By a mix of indigenous PHWRs & FBRs and LWRs based on foreign technical cooperation)

- **Beyond 2032, large capacity addition based on FBRs and thorium based reactors**
Obstacles in the path of Science → Inclusive Development

• Gap in science - innovation - deployment cycle
  – Lack of knowledge
  – Absence of appropriate agencies / entrepreneurs
  – Not a part of established economic model
  – Viability gap / Sustainability issues

• Value system
  – Limited recognition as a scientific activity
  – Urban / rural, class divides
Nuclear is green
Thank you
Water Recharging - Types

Recharge → To add water to an aquifer/spring

- Natural Recharge
- Artificial Recharge
- Incidental Recharge

Natural Recharge - Infiltrated water into Water Table [saturation zone]

Artificial Recharge - Deliberate act of adding water

Incidental Recharge - Water added due to human activities (e.g., irrigation return-flow)
Water Recharging Process is governed by:

- Soil Type
- Geology
- Precipitation
- Topography
- Vegetation
Pictorial representation of various routes of water recharge
Recharge Process- Understanding and Estimation

Whether current recharge (replenishment) takes place or not.

- If yes, how much and what are the sources and their origin?
- If no, ways of augmenting the replenishment, if feasible

Environmental isotope approach- *Gives regional-scale information*

- $^2$H, $^{18}$O, $^2$H, $^{18}$O, $^{13}$C, $^{14}$C, $^{36}$Cl, $^3$He, $^{81}$Kr, etc.

Artificial tracer approach- *Gives site-specific information*

- Radioactive tracers ($^{60}$Co, $^{82}$Br, $^{131}$I, $^3$H, etc.)
- Chemical tracers (Chloride)
Isotopes

• British physicist **Frederick Soddy** clarified the concept of isotopes in 1910.

• Atoms with same atomic number \([Z]\) and different mass number \([A]\). Written as \(\text{Mass Number} \times \text{Atomic Number}\)

• Unstable isotopes are called **Radioisotopes** or **Radionuclides**. They emit \(\alpha, \beta\) & \(\gamma\)-rays

• Both stable and unstable isotopes are used for Hydrology applications.
Environmental Isotopes

Isotopes (stable, radioactive) which occur in the environment in varying concentrations, over which the investigator has no control are called Environmental Isotopes.
### Environmental Stable Isotopes

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Abundance in nature (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deuterium (^{2}\text{H})</td>
<td>0.015</td>
</tr>
<tr>
<td>Oxygen - 18 (^{18}\text{O})</td>
<td>0.204</td>
</tr>
</tbody>
</table>

Stable isotopic composition is generally remain unchanged, unless it mixes with the other sources, which are having different isotopic composition.

These isotopes are used for identification of source and origin of groundwater.
Factors affecting stable isotopic composition in rainwater

- Altitude effect
- Latitude effect
- Amount effect
- Continental effect - Distance from the coast
- Seasonal effect

These are temperature dependent.
**δ – Notation and SMOW**

Standard Mean Ocean Water (SMOW) is used as reference. Abundance of $^{18}$O and $^2$H in environment is:

\[
^{18}\text{O} = [1993 \pm 2.5]^{10^{-6}}
\]
\[
^2\text{H} = [158 \pm 2]^{10^{-6}}
\]

For hydrological applications, the absolute abundance ratio of stable isotopes is not usually measured. The difference in the ratio of the heavy stable isotope to the more abundant lighter stable isotope of the sample with respect to SMOW is determined and is expressed in “$\delta$” (parts per thousands ($\permil$)).
# Environmental Radioisotopes

<table>
<thead>
<tr>
<th>ISOTOPES</th>
<th>T&lt;sub&gt;1/2&lt;/sub&gt; (years)</th>
<th>Energy (MeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tritium ((^3)H)</td>
<td>12.43</td>
<td>$\beta$ 0.019</td>
</tr>
<tr>
<td>Carbon - 14 ((^{14})C)</td>
<td>5730</td>
<td>$\beta$ 0.156</td>
</tr>
<tr>
<td>Chlorine -36 ((^{36})Cl)</td>
<td>$3.1 \times 10^5$</td>
<td>$\beta$ 0.714</td>
</tr>
</tbody>
</table>

These isotopes are used for groundwater dating.
Production of Environmental Radioisotopes

**Tritium** - $^3$H is produced in the atmosphere by cosmic ray neutrons reaction with nitrogen atoms. It is oxidized to water and incorporated in the rain.

$$^{14}N_7 + ^1n_0 \rightarrow ^3H_1 + ^{12}C_6$$

- Also it is produced by the atmospheric explosion of thermonuclear devices, operation of nuclear reactors and particle accelerators.

**Radiocarbon** - $^{14}$C is produced in the upper atmosphere by cosmic ray neutrons reaction with nitrogen atoms. It is oxidized to carbon dioxide and incorporated in the carbon cycle.

$$^{14}N_7 + ^1n_0 \rightarrow ^1H_1 + ^{14}C_6$$
### Application of Artificial Radioisotopes

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half life</th>
<th>Chemical form</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^3$H</td>
<td>12.43 y</td>
<td>HTO</td>
<td>Groundwater recharge rate and flow direction</td>
</tr>
<tr>
<td>$^{60}$Co</td>
<td>5.3 y</td>
<td>$K_3[Co(CN)_6]$</td>
<td>Groundwater recharge rate</td>
</tr>
<tr>
<td>$^{82}$Br</td>
<td>36 h</td>
<td>$NH_4Br$</td>
<td>Ground water velocity</td>
</tr>
</tbody>
</table>
Facilities Required

- Isotope ratio mass spectrometer
- Liquid scintillation counter
- Ion chromatograph
- Field kits (T/EC/pH/DO meter)
Radioactive isotopes [tritium ($^3$H) and carbon-14 ($^{14}$C)] can be measured.

MDL for tritium is 0.5 T.U. and C-14 is 1 pmC.

Stable isotopes such as $^2$H, $^{18}$O, $^{13}$C, $^{15}$N and $^{34}$S can be measured.

Precision for $\delta^{2}$H is 0.1 ‰ and $\delta^{18}$O is 0.5‰.
Isotope Methodology

Recharge source
High altitudes, Far away from coasts, Intense rains- **Characterized by depleted isotope (\(^{18}\text{O},\ ^{2}\text{H}\)) signature**

Interconnections
Similar values of isotope (\(^{18}\text{O},\ ^{2}\text{H}\)) and chemical data **suggest interconnection**
Dissimilarity -> **No interconnection**
1) Recharging of Drying Springs in Mountainous Region of Gaucher, Uttarakhand

**Problem** - In mountainous region of Gaucher area, Uttarakhand, drying of springs in summer causes a lot of hardship to the people.

**Objective** - Isotope investigation was carried out to identify the recharge areas of the drying springs (10 Nos.)

**Isotopes Used**: $^{18}O$, $^2H$ (Identification of recharge altitude based on altitude-effect in precipitation [$-0.55\%\text{ per } 100\text{ m rise in altitude}$ for $\delta^{18}O$ and $-3.8\%\text{ per } 100\text{ m rise in altitude}$ for $\delta^2H$]. $^3H$ (Estimation of groundwater residence time)

Based on isotope results, artificial recharge structure were constructed at identified recharge areas for rain water harvesting.
Case Study

Recharge of drying springs in Himalayan region

- **Outcome**: Enhanced & perennial spring discharge (2 New springs appeared)

- Similar work initiated at 10 new locations in Uttarakhand, Jammu & Kashmir, Himachal Pradesh and Sikkim. **Results awaited in November 2013 (after monsoon)**

- Isotope Hydrology Centre has been set up at HESCO, Dehradun to train the local people to carry out similar work by themselves
2) Transforming Dry to Cultivable Areas in Amaravati district, Maharashtra State

**Issue:** In Amaravati district, very low groundwater potential and also of saline nature → farmers drill boreholes up to 100-150m, most wells fail → struggle for fresh water in the region → drastic decline in groundwater levels due to large scale exploitation.

**Findings & Outcome:** About 10 km south of Chinchona hill range, a huge groundwater sanctuary identified (and also confirmed by geophysical survey) → local authority drill bore hole of 60m depth at identified site → yield ~30,000 L/h, a perennial source of good quality water supply to 5-6 villages [for about 30,000 people] for drinking and irrigation.
3) Evaluation of Recharge to Very Deep (>500 m) Groundwaters of Tiruvadanai in Tamilnadu

In collaboration with Tamilnadu Water Supply and Drainage Board, Government of Tamilnadu

Findings

• Modern recharge to the aquifer (supplying drinking water to over 600 villages in Ramanathapuram Dist.) is very low.

• Freshwater bearing deeper confined aquifer contain fossil waters (>30,000 years), i.e. not part of actively recharged flow systems, and hence the resources may be finite and their current exploitation will lead to mining.

• Suitable river for planning large-scale artificial recharge measures could be northern river rather than the southern river.
4) River-groundwater interactions

Groundwater contribution (m) to river can be estimated using a 2-component mixing model:

\[ R_{AM} = mR_1 + (1-m)R_2 \]

- \( R_1 \) - \( \delta \)\(^{18}\)O of river water
- \( R_2 \) - \( \delta \)\(^{18}\)O of groundwater
- \( R_{AM} \) - \( \delta \)\(^{18}\)O of admixture (GW+RW)

Investigated area

Interaction of River Ganga with groundwater (Haridwar to Narora), Lake-groundwater interaction (Nanital, Uttarakhand)
5) Efficacy of water recharge measures

OBJECTIVE

To investigate effectiveness of artificial recharge structures at Hinganigada Tank (Maharashtra)

Major findings

The artificial recharge structures were found to be effective and impact is noticed up to 2.2 kms from the Dam
6) Quantification of recharge by artificial radioisotope tagging

Recharge rate,

\[ R(\%) = \frac{d \cdot \theta \cdot D \cdot 100}{P} \]

\( \theta \) = Average soil moisture content \((m^3/Kg)\)

\( d \) = Displacement \((cm)\)

\( D \) = Bulk density of soil \((Kg/m^3)\)

\( P \) = Precipitation \((cm)\)
Objectives
1) Delineating Recharge Zones
2) Identifying Recharge Levels (altitude)
3) Estimating reservoir temperature from $^{18}$O Shift from the meteoric water line

In collaboration with M/s. Thermax, PUNE
Advances in isotope hydrology

Liquid water analyzer for stable isotopes

Salient features

• Very precise
• Robust
• Simpler to operate and maintain
• High sample throughput
• No high vacuum needed
• Simultaneous measurement of both water isotopes (δ²H & δ¹⁸O)
• Low cost equipment
• Alternative to the conventional mass spectrometer
Estimation of 3H/3He ages of the groundwater

- To quantify the groundwater residence times up to 50 years with an accuracy of ± 1 year
- Helps in calibrating the groundwater flow models
## Nuclear Techniques for Enhancing Water Supply

### Isotope Hydrology
- Identification of recharge areas
- Establishment of flow-path
- Aquifer identification

### Nuclear Desalination
- Low pressure steam
- Waste heat

### Water Purification
- Micro and Nano filtration
- Reverse Osmosis
Rudraprayag
Recharging the Drying Springs

Gaucher, Uttarakhand, India

Issue: Seasonal springs, dry in Summer
Nuclear Desalination

Energy input: Waste heat

Schematic Diagram of Low Temperature Evaporation (LTE) Desalination

Key Features:
• Energy input: Waste heat
• No chemical requirement
• Small capacity plants
Nuclear Desalination Demonstration Plant (NDDP) Kalpakkam India - MSF Section

- **MSF Stages:** 39
- **Gain Output Ratio (Kg steam/ Kg water):** 10
- **Energy cost:** < 1 cent/10L distilled water
- **Product Quality:** Distilled water
- **Operating range:** 50-100% design capacity
Multi-Effect Distillation (MED) Sea water Desalination Plant at Trombay (India)

Key Features:

• Capacity: 50 KLD

• No chemical requirement

• Product quality: Ultra-pure water
Advantages of Hybrid Desalination

Advantages:

- Two qualities of product water:
  1. Distilled water for high end applications
  2. Better quality potable water through blending
- Better redundancy
- Sharing of facilities
- Longer membrane life
Membrane Developed (Indian Patent Nos. 186210; 186375; 194101)

BARC developed Ultra-Filtration (UF) membrane elements (Capillary Module)

Membrane Casting Machine & Membranes (Spiral Module) Developed in BARC
Water Purification Devices for Removal of Fluoride, Arsenic and Iron

- Iron removal (Purified water <0.3 ppm as per WHO standard)
- Fluoride removal (Purified water <1 ppm as per WHO standard)
- Arsenic removal (Purified water <10 ppb as per WHO standard)

Module Capacity: 5 KLD

Technology for fluoride, iron as well as arsenic removal has been transferred to private parties for wider deployment.
Water Purification at Community Level in Remote Locations (without electricity)

A Village in Maharashtra

Manipur
Problem: Brackish Water RO

Desalination Plants

Community size (KLD)

Technology has been transferred to private parties.

Tempo/ Truck/ Trailor Mounted Desalination Unit Developed by BARC

Capacity: 5 KLD; Chandrapadi village, Nagapattinum Tamilnadu

Desalination plants for tsunami hit villages

Capacity: 5 KLD; Nagapattinum Tamilnadu
Field Testing in Punjab with BARC developed & Patented Membrane Based Technology for Removal of Uranium

Uranium removal was carried out from raw water containing up to 700 ppb U to product water containing <60 ppb U as per AERB standard.

Field trials were carried out in six districts in the State of Punjab viz Ferozpur, Faridkot, Muktsar, Bathinda, Mansa and Moga. A total 24 nos. of tube well water samples were collected from different villages in these districts.

Patent No. 186375: “A process for the manufacture of an unsupported, integrally skinned asymmetric semipermeable etheramide hydrazide polymeric membrane for use in reverse osmosis”.

Membrane based System
ISO 9001
2008

MATHERAN
March 2007
5MT/day
HIRANANDANI ESTATE, THANE

- 5MT/day hotel and vegetable market material
- Area 300 m²
- Biogas for electricity
- December 2005
TIFR, COLABA
December 2006
1 MT/day
Earth needs your help
TCS, THANE

- 1MT/day Food resource from TCS canteen
- Area 40 m²
- Biogas for Kitchen
- June 2009
2 MT/day kitchen and market waste

Biogas used in kitchen

June 2008
SOLAPUR (AL_QURESH) ABATT

5 MT/day

Abattoir material

December 2009

Boiler and kitchen
5 MT/day
200 m²
Bone powder based
June 2010
KOZHIKODE [RPRC]

- 1MT/day hotel and vegetable market material
- Area 100 m²
- Biogas for kitchen
- March 2009
Cochin Refinery Nisargruna biogas plant

- 1MT/day hotel and vegetable market material
- Area 100 m²
- Biogas for kitchen
- March 2009
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Burden of Dirty Fuels

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- Adults suffering
  - 16% from Bronchitis
  - 5% from Bronchial asthma
  - 8.2% from Pulmonary TB and
  - 7% from Chest infection

- Risk of contracting respiratory diseases and eye diseases increases with longer duration of bio-fuels
Inclusive Development... (contd.)
Strategy for Better Health

• **Clean Water for All**
  – Despite 95% coverage, large number of slip backs (2.8 lakhs) and serious quality problems (2.17 lakhs)
  – Need to move away from ground water to surface water sources
  – Emphasis on community owned & managed projects
  – States need to fully utilise 12th Finance Commission funds

• **Sanitation**
  – Total sanitation campaign has increased coverage from 4% in 1988 to 35% at present
  – Subsidy only for BPL; greater focus on APL needed
Inclusive Development
Rural Infrastructure
NON POWER APPLICATIONS

- Agriculture
- Food Preservation
- Drinking Water
- Health Care
- Isotopes
- Waste Management
Radiation damage on DNA

Lethal DNA damage
- Cell death
- Food preservation

Non-lethal DNA damage
- Mutation
- Crop Improvement
Mutation results in a large gene pool of plant germplasm with varying characters such as:

- Altered seed size or colour or oil composition
- Enhanced yield
- Tolerance to diseases/drought,
- Altered plant height
- Early maturity

Breeder can combine these characters to develop new crop varieties
Varieties with improved yield, earliness, large seed size, resistance to biotic and abiotic stress, suitable for rice fallows.
TROMBAY URDBEAN (Blackgram)

VARIETY TAU 1

Very popular in Maharashtra occupying around 5 lakh hectares
Most Popular Trombay Mung

**TARM-1**
Tolerant to Powdery Mildew (PM), Mungbean Yellow Mosaic Virus (YMV) disease.
Maharashtra, Gujarat, MP, AP, Kerala Karnataka, Tamil Nadu, Orissa

**TMB 37**
Released for WB, UP, MP, Bihar, Jharkhand, Assam, Early maturing, for rice fallow and kharif/summer seasons,

**TJM-3**
High Yielding & resistant to PM, YMV & Rhizoctonia root rot diseases MP

**TM-96-2**
High yielding, PM resistant & suitable for rice fallows. AP
Trombay Groundnut Varieties:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Drought tolerance; Wider adaptability</th>
<th>High shelling%, Stem rot tolerance</th>
<th>Large seed, High oleic acid</th>
<th>Early maturity, High shelling%</th>
</tr>
</thead>
<tbody>
<tr>
<td>TG 37A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TG 38</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>TPG 41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TG 51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- WB, Gujarat, Rajasthan, UP, Punjab, Haryana, Orissa, Bihar, NE States
- WB, Orissa, Bihar, NE States
- All India
- WB, Orissa, Bihar, NE States
Dissemination of Trombay Crop Varieties
Radiation inactivates DNA in germination centres of tubers and bulbs (0.03 – 0.15 kGy)

Delay in ripening: Radiation inhibits formation of the ripening hormone ethylene

Radiation inhibits hatching of eggs and all developmental stages of storage insects by inactivating DNA
Killing of insects for quarantine purpose for export of fruits (400 Gy)
Microbial Disinfestation of Spices (6-14 kGy)

RADIATION PROCESSING PLANT
Vashi, Navi Mumbai
RADIATION PROCESSING
One Process

- Sprout Inhibition
  Onion, Potato, ginger, Garlic

- Insect Disinfestation
  Cereals, Pulses, Dry Fruits

- Shelf-life Extension
  Chicken, Meat, Fish

- Quarantine
  Fruits

- Hygienization
  Spices, Meat, Fish

Multiple Uses
Endorsement of Radiation Processing Technology by World Bodies

1980 WHO\FAO\IAEA JECFI CONCLUDED THAT IRRADIATION OF ANY COMMODITY UP TO AN OVERALL DOSE OF 10 kGy PRESENTS NO TOXICOLOGICAL HAZARDS AND INTRODUCES NO SPECIAL MUNTRITIONAL OR MICROBIOLOGICAL PROBLEMS

1983 CODEX ALIMENTARIUS COMMISSION ADOPTED JECFI RECOMMENDATIONS


1997 ENDORSED THE SAFETY OF USING DOSES HIGHER THAN 10 kGy (WHO 1999)

2003 ADOPTION OF REVISED CODEX STANDARD
Healthcare Equipment

- **Bhabhatron** – indigenous telecobalt machine
- 12 machines are in operation
- Many more in pipeline

**Tele ECG machine**

Technology transferred for commercial production
I-125 sources for brachytherapy of Ocular Cancers

- 0.5mm (φ) x 3mm (l) silver rods are coated with I-125 (typically 111MBq/3 mCi/seed), encapsulated in 0.8mm (φ) x 5 mm (l) titanium capsules of 50 micron thickness by laser welding

- Several (15-25) such seeds are glued to a gold plaque custom-made to suit the size of the patient's eye

- The plaque is sewn into the eye to deliver 40-60 Gray of radiation dose and then removed (typically 8-12 days)
Radiopharmaceuticals Currently In Vogue

I-131 : For Thyroid disorder diagnosis and treatment

P-32 : For reducing pain of cancer in bone marrow

I-131 Labelled compounds : For cancer treatment of various organs

Ho-166 labeled to Hydroxy Apatite : to relieve pain and inflammation in arthritis patients

P-32 labeled to Samarium colloid : being developed for treatment of Joints.
Desalination Plants with Different Technologies

**MED-VC desalination plant**
Commissioned (50 m³/day)

**LTE-CT desalination plant**
Commissioned (50 m³/day)

**NDDP-MSF, Kalpakkam**
(4500 m³/day)

**NDDP-MSF Modules with MAPS in the background**

**Barge Mounted RO Desalination Plant**
Recharging of Mountain Springs

Identification &
in Gaucher,
Uttarakhand
Using Isotope
Hydrology
Urban & Rural Waste Management

• 20,000 cu.m of sewage sludge treated and 800 tonnes of pathogen free manure produced (2007)
• Sludge has been tested as manure in agriculture fields
• Plan to set up several sewage treatment plants under J N National Urban Renewal Mission

The hygienized sludge is an ideal medium to grow nitrogen fixing bacteria like Rhizobium and hence can be converted easily into a bio-fertilizer.

<table>
<thead>
<tr>
<th></th>
<th>Un-irradiated (counts/ml)</th>
<th>Irradiated (counts/ml)</th>
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</thead>
<tbody>
<tr>
<td>Total Bacteria</td>
<td>$2 \times 10^6$</td>
<td>$8 \times 10^2$</td>
</tr>
<tr>
<td>Fecal coliform</td>
<td>$1 \times 10^5$</td>
<td>38</td>
</tr>
<tr>
<td>Rhizobium</td>
<td>$4 \times 10^7$</td>
<td>$9 \times 10^9$</td>
</tr>
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Sludge Hygienisation Research Irradiator (SHRI) at Vadodara for sewage water treatment
• This 5 tonnes/day plant can process any biodegradable waste (Kitchen, Vegetable market, Agricultural residue, Abattoir waste) and produce high quality methane and manure (about 10% of the total waste processed)

• 42 plants of varying capacities are operational and about 50 plants are under various stages.
The Socio Economic Divide
• Preparing for an India of 2030
  – With reduced disparities of per-capita income
• Challenge for Indian Science, Technology and Innovation system
  – to balance between the discovery science through competitive excellence and solution science through collaborative excellence
• International S&T cooperation is a tool being more actively explored than earlier
  – Reciprocity and parity form the adopted principle
• Public Private Partnership for R&D and Clean Energy is a stated policy direction
  – New relationship model is being examined
Current Status of Eight-part Indian STI System

- **Mission mode Agencies**: Focused on self reliance, under transition in the era of techno-globalism
- **Government Agencies**: Focused on the balancing in the art of funding and developmental roles in scholarship focused science, market driven technology and competition linked innovation system
- **Academic sector**: Challenged by need to expand many fold without dilutions of excellence and loss of focus on research
- **Socio economic ministries seeking solutions from science**: Challenged by mis-matched rates of scientific development and societal absorption of global solutions
• Mission mode R&D in non strategic sector: Transition from command economy models to dynamic global competition in a weak technology demand status
• Industrial R&D systems: Lower levels of private sector investment into R&D and challenges of enhancing value addition to raw materials through innovation driven manufacturing
• R&D by MNCs: Taking advantage of low expertise costs for IP generation for global use
• R&D by NGOs: Sustaining high manpower costs and R&D infrastructure in a largely public funded R&D landscape
Some Key Steps in Education Sector since 2004

- Establishment of large number of new institutions of excellence: 8 new IITs, 5 IISERs (equivalents IISc), 14 new national universities….

- Allocation of 19.8% of Gross Budgetary Support to Education and providing a 9 fold increase of funds for tertiary education

- Expanding the educational infrastructure at all levels for increasing the Gross Enrollment Ratio

- Enunciation of “Right to Education Bill” and many more
Social Sector: E-Education
Primary Health Care
Social Sector: Healthcare
Social Sector: Waste Remediation
Information Science & Technology as a 'Driver' for Inclusive Growth
Information and Communication Technology

![Pyramid Diagram]

- Data
- Information
- Knowledge
- Wisdom
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Balancing Inclusiveness with Competition

Competitiveness
- Differentiating mind set
- Market advantages
- Inventor focused
- Return for Investors
- Short life spans
- Value maximization
- Speed is USP
- First mover advantage
- Small economies excel

Inclusiveness
- Integrating mind set
- Availability to users
- People focused
- Return to society
- Long gestation time
- Input optimization
- Goodness is USP
- Last mile connectivity
- Relevant to large population
Several initiatives are being proposed to ramp up Indian enrolment into Higher education and meet the high demand for faculty positions.

- 19.8% of Gross Budgetary Support to Education
- 20-25% CAGR in public expend into R&D since 2004

Innovation in Science Pursuit for Inspired Research

Science and Innovation Scholarship to more than Million people
Four part Approach to Innovations

- **New Millennium Indian Technology Leadership Initiative:** PPP model for global referencing
- **Venture fund support system:** Technology Development Board equity participation model
- **Grass Root Innovation:** National Innovation Foundation involving 2,50,000 grass root innovators
- **National Innovation Council:** For global bench marking and alliances

Cotton Stripper from grass root innovation

Health care products from formal innovation system
Some recent and good examples from Indian innovation system

Nano Car: 2500 US $ car from Tatas for providing an opportunity for middle income families

Jaipur foot: Affordable prosthetics @ US $ 28

Hepatitis Vaccines: 40 cents a dose product giving health care access to large number of people with low purchasing power
Jaipur Foot: A case of disruptive affordable innovation from India
Affordable Innovations for Public and Social good under PPP

- Agriculture for food and nutrition security
  - Water and land saving agriculture; Avoiding food wastes
- Affordable human health care
  - Extremely low cost solutions to human health care challenges; Diseases suffered by people with low purchasing power
- Technologies for clean energy
  - Renewable energy systems; Enhancing energy efficiency in use; high focus on solar energy
- Innovations for sustainable environment
  - Zero emission in industrial production; Atom and Energy efficient manufacture
- Innovative deployment of technologies for water security
  - Technology agnostic approaches for sustainable solutions
High Technology-led paths

- Nano Science & Technology
- Micro and nano scale manufacturing
- Technologies like Lasers and Accelerators
• Strengthening linkages among science and socio-economic sector through Shared vision
• Joint missions
• Delivery and deployment of co-generated values
• Establishing State Center Technology partnerships
• Linking to states through various mechanisms and strengthened ties with State Councils and NGOs; especially for technologies for Rural India
Challenge Ahead

motivating scientists to
discover solutions

Thank you
Inclusive Growth
Basic Attributes

- Reduce Poverty
- Improve Quality of Life
- Equitable Sharing Across Class Division
- Equal Access to Economic and Social opportunities
- Long term perspective and Sustainability in growth strategy