

# **Radiation Technology Applications for Healthcare, Environment and Industry**



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*To Vigyan Jyoti Scholars - 8/06/2021*

# Bhabha Atomic Research centre





Dr. Homi Jehangir Bhabha  
30/10/1909- 24 Jan. 1966

# India

## Young India



- 330 millions in 1947
- 1350 millions in Feb.2019
- 1/6 of the world's population
- About half of the population lives in cities
- More than 50% less than 25 years, average age by 2020 – 29 years

Our requirements are huge and so are the problems. Technology solutions are the most important means to make India an advanced country.

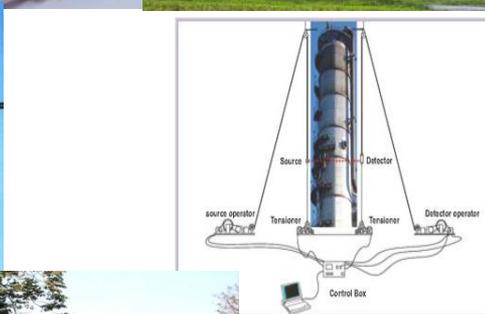
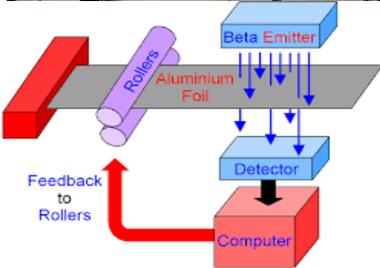
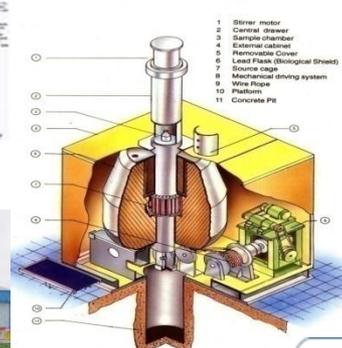
Isotopes and Radiation  
Technology are being  
used world over for  
societal benefits and also  
generate billions of Dollar  
Business

# Major Area of Applications of Radiation Technology

- Industry
- Healthcare
- Environment
- Agriculture

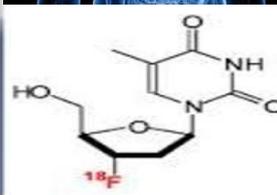
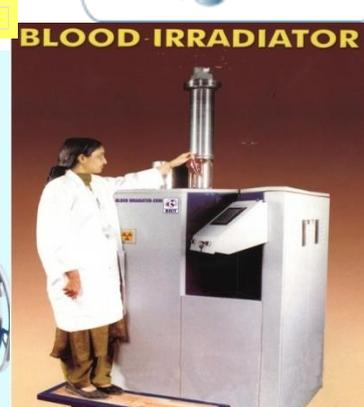
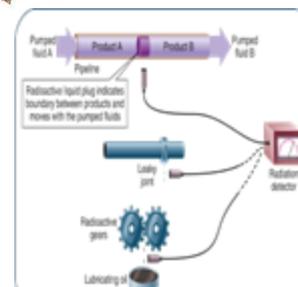
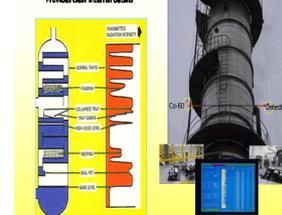
# Some well known Radiation Technology Applications are:

- \* Medical products sterilization
- \* Food preservation
- \* Wires and cable crosslinking,
- \* Sewage and sludge hygienisation
- \* Effluent treatment etc.
- \* Advanced materials



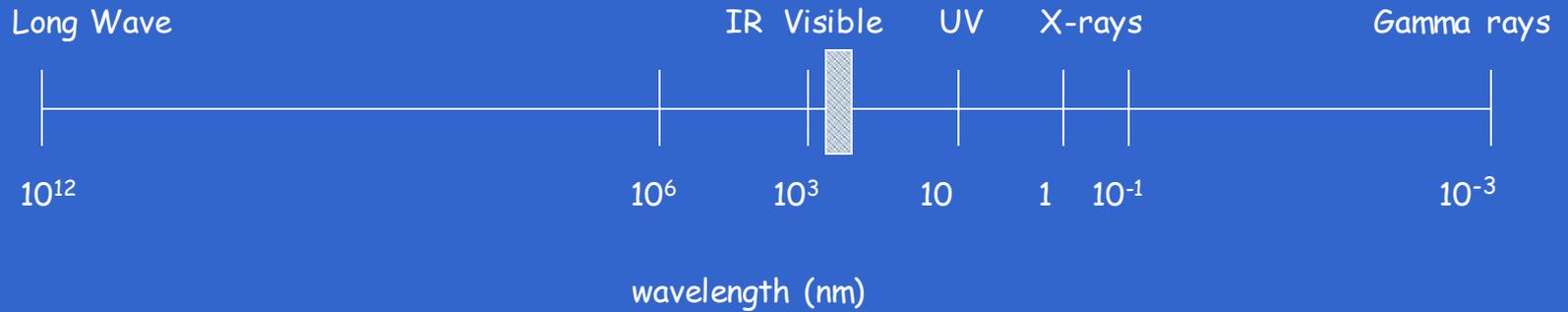
### GAMMA COLUMN SCANNING

Provides clear internal details



### BLOOD IRRADIATOR

Science



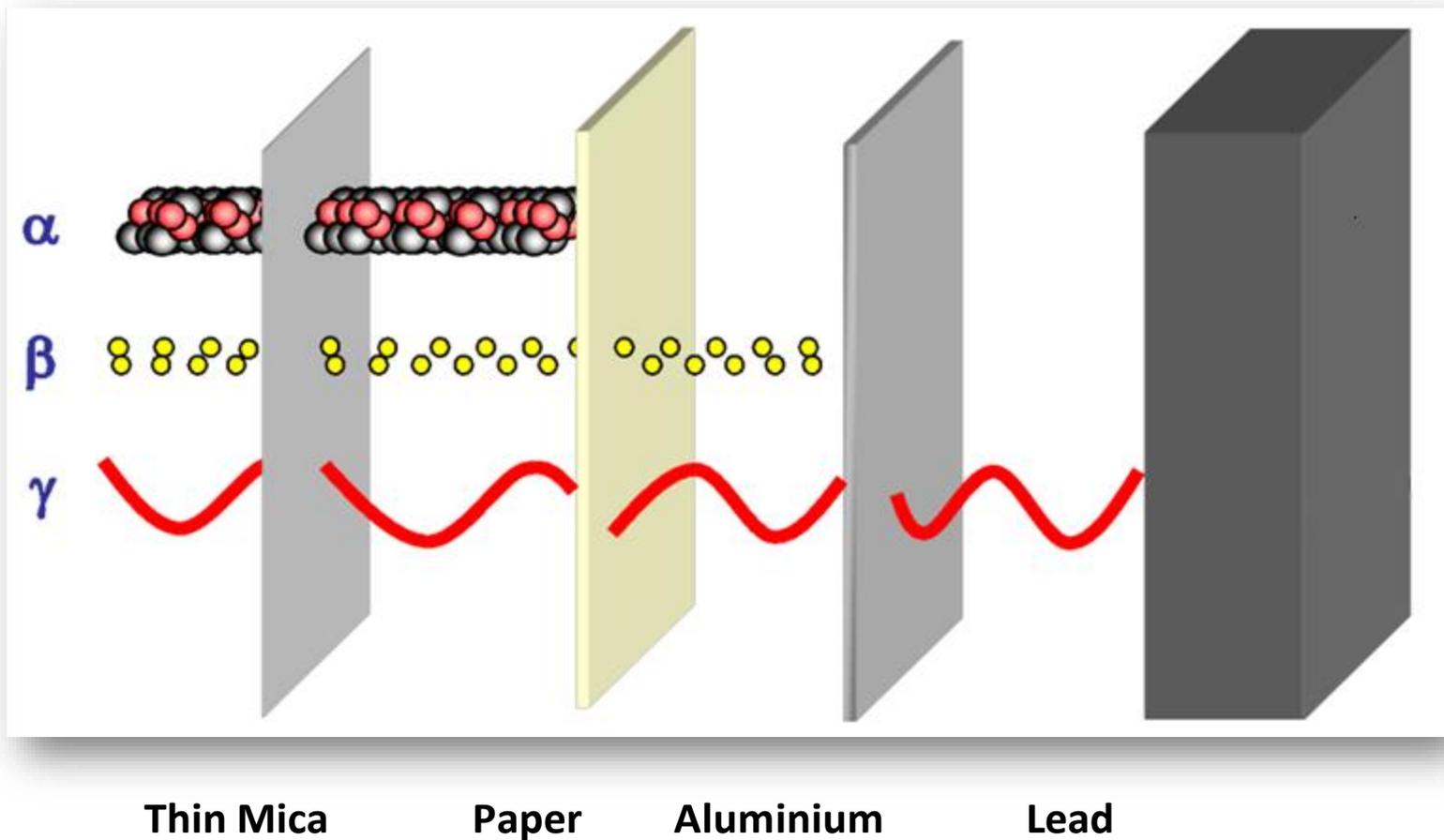
**Gamma-rays**



Energy of a Gamma photon is about million times than a visible photon

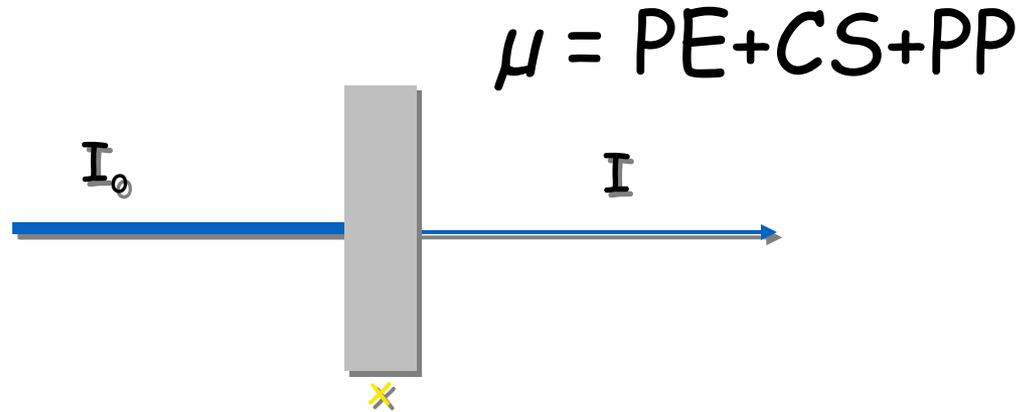
**absorption**

# Penetration power of the Radiations



# Absorption

Gamma ray



$$I/I_0 = e^{-\mu^* x} = 1/e^{\mu^* x} = 1/e^{\mu \rho x}$$

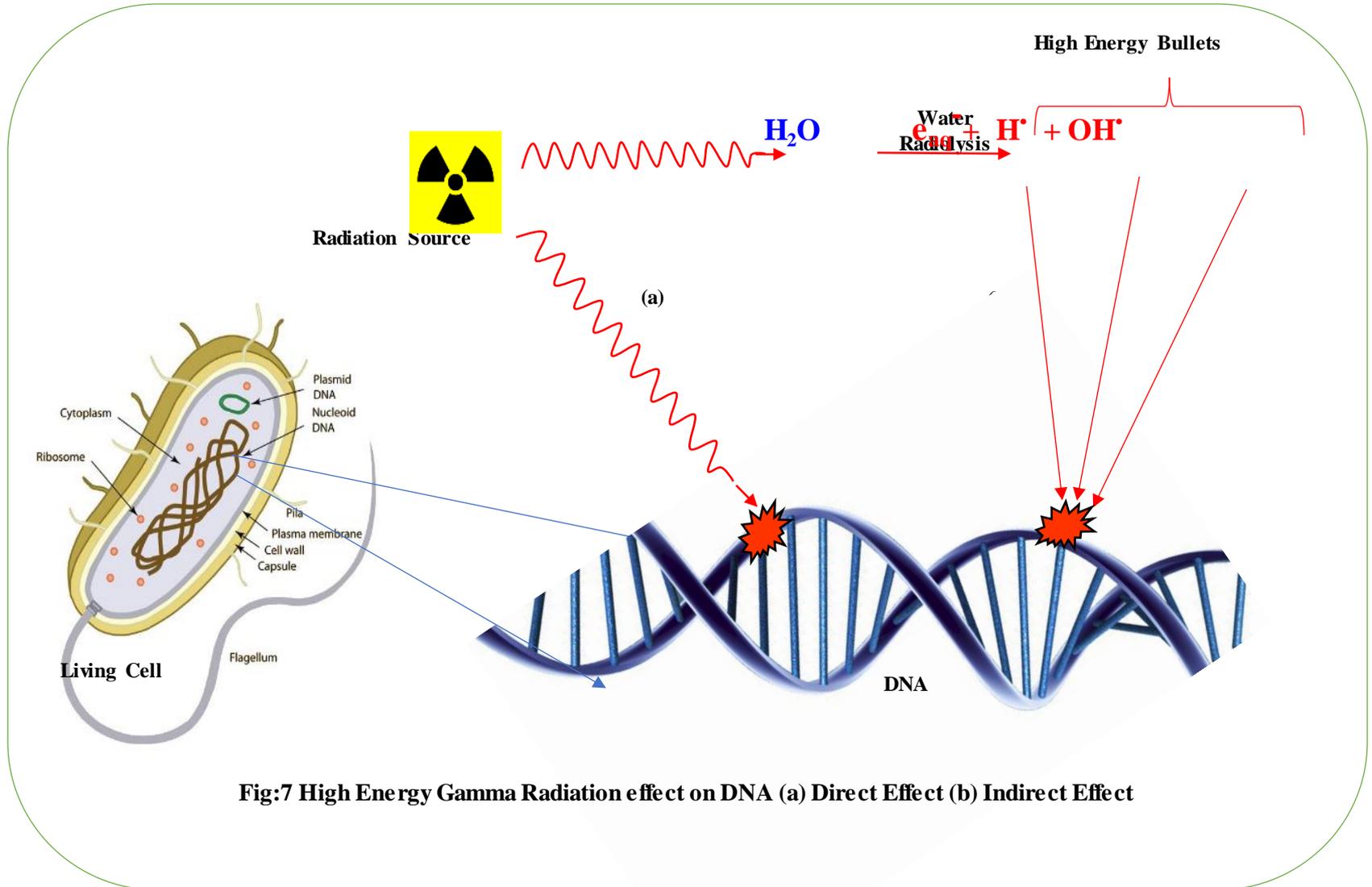
$\mu^*$  = linear attenuation coefficient

$\mu$  = mass attenuation coefficient

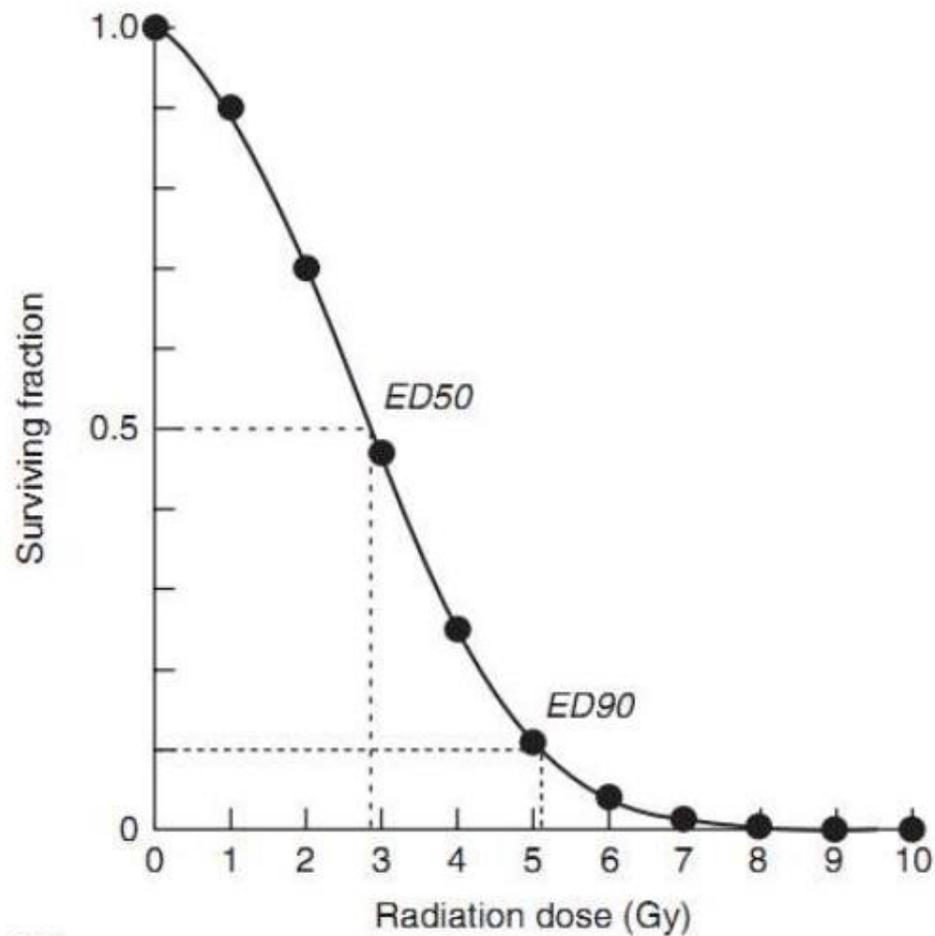
$\rho$  = density of absorber

# Two Important Interactions of High Energy Radiation with Materials

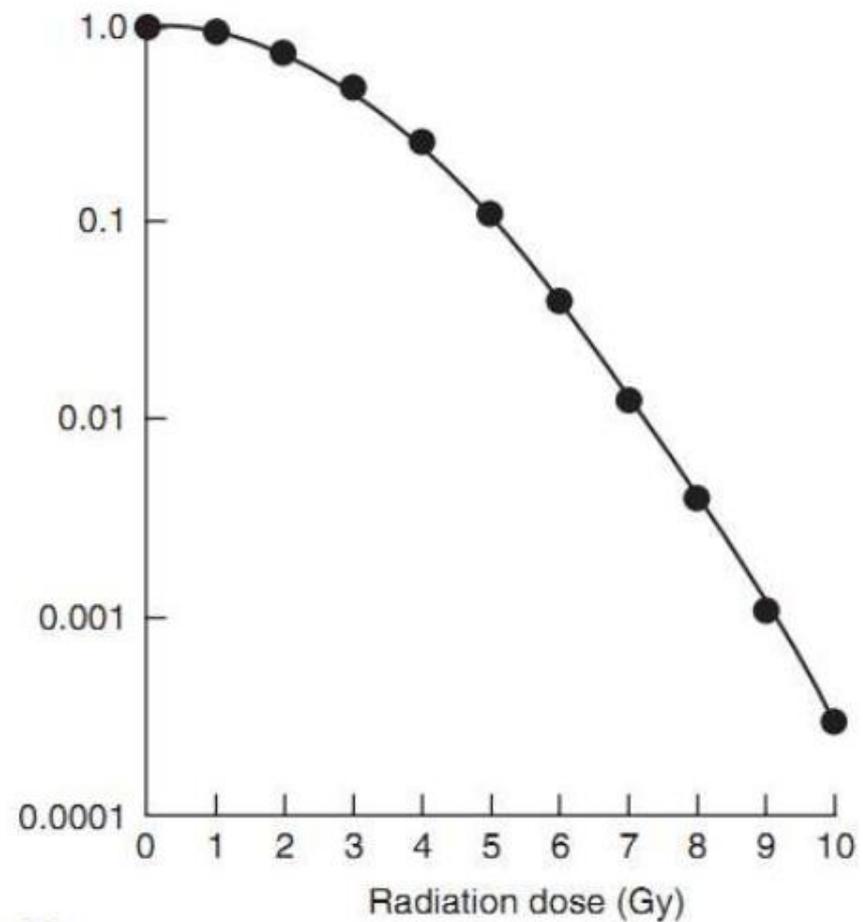
# Direct and Indirect action of Radiation on DNA



**Fig:7 High Energy Gamma Radiation effect on DNA (a) Direct Effect (b) Indirect Effect**



(a)



(b)

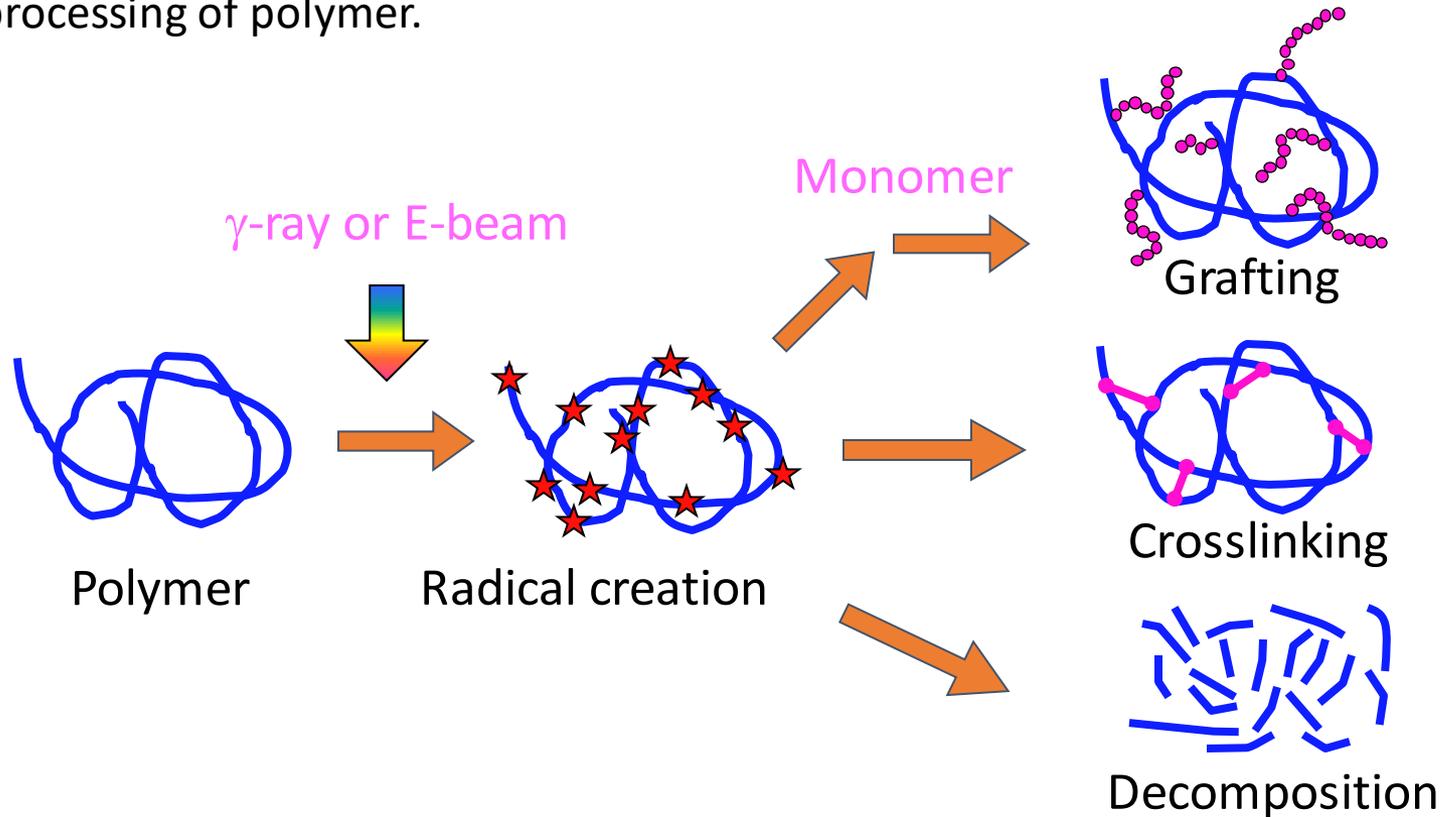
**Figure 4.3** A typical cell survival curve for cells irradiated in tissue culture, plotted (a) on a linear survival scale. (b) The same data plotted on a logarithmic scale.

# Radiation Dose(Gy)

- Human < Fungi < Bacteria < Virus
-

# Radiation processing of Polymer

Grafting, crosslinking, and degradation are major reactions in radiation processing of polymer.



- Grafting : Any shapes (membrane, cloth, and fiber)
- Crosslinking : Any states (solid and sticky liquid)
- Degradation : w/o Chemicals

# What Irradiation can do.....

- It can inactivate cells/kill pathogens/bacteria/virus /fungi
- Sterilize medical products and food
- Degrade chemicals and plastics
- Reduce foul smell
- Cross link plastics and biopolymers
- Form Hydrogels

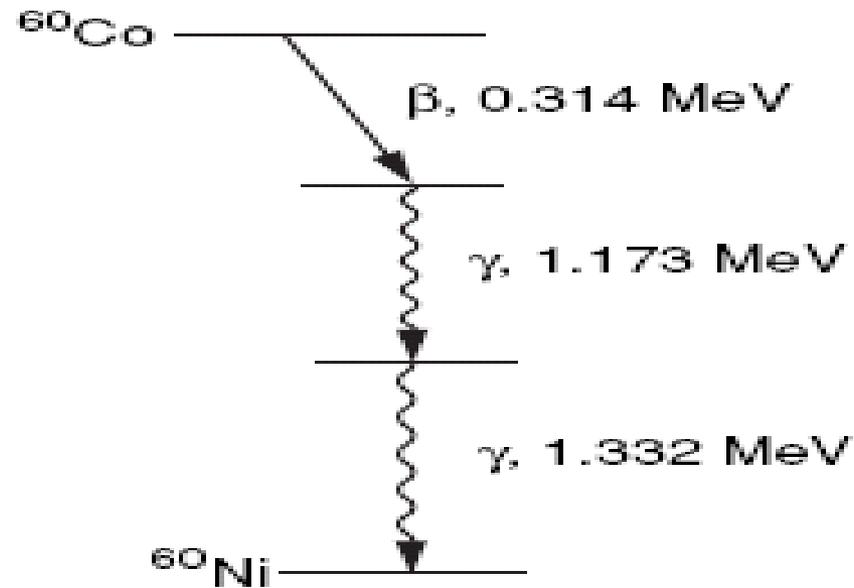
# Technology

# Sources of High Energy Radiation for Industrial Processing

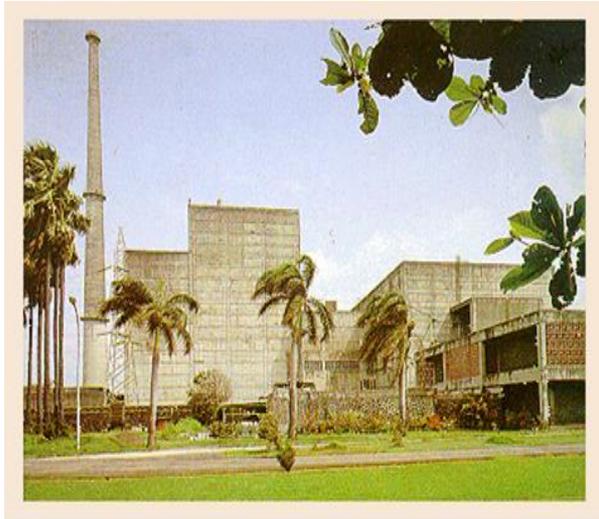
- ❑ Nuclear Reactor Produced Isotopes  
Cobalt-60, Cesium 137
- ❑ Electron Accelerators  
Linacs, Rhodotrons

# Production of radioisotopes

## Nuclear reaction of Cobalt with neutron



Cobalt-60 decay scheme.



**TARAPUR-1&2**



**RAJASTHAN-1 to 6**



**MADRAS-1&2**



**NARORA-1&2**



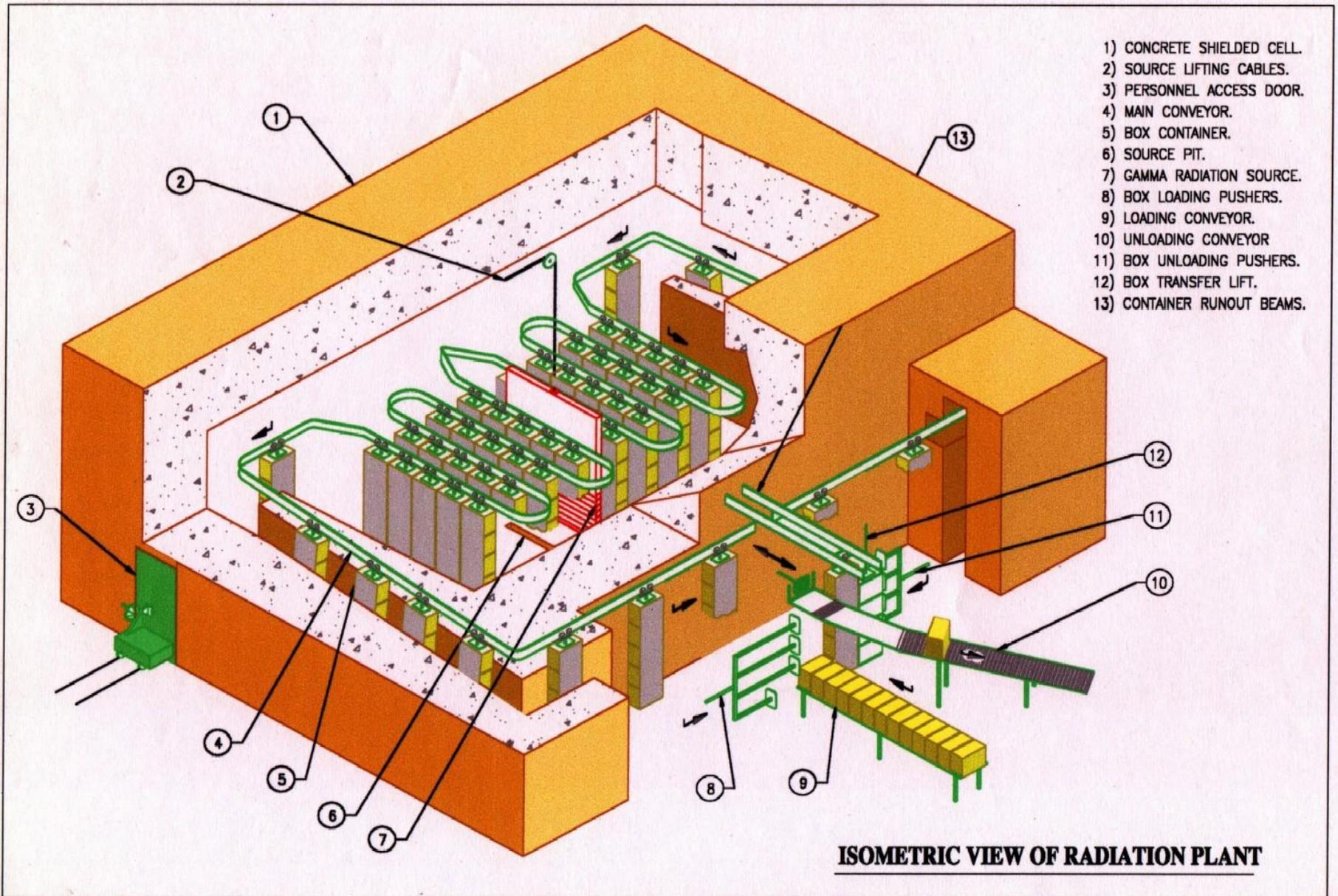
**KAKRAPAR-1&2**



**KAIGA-1 to 4**

ISOMED, Trombay

Panoramic, Dry Source Storage (Cat.II)



# RADIATION PROCESSING PLANTS- UNDER OPERATION



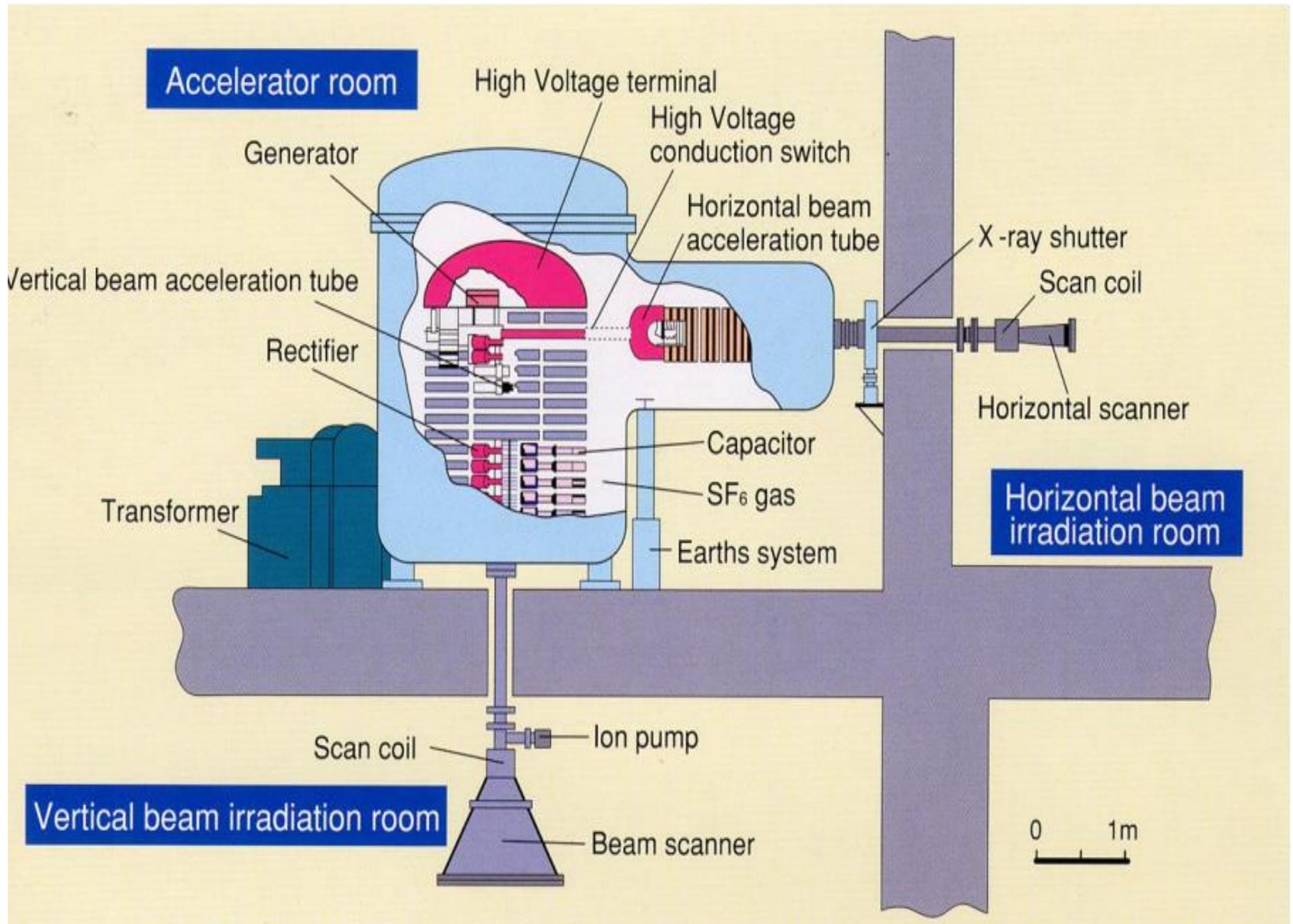
**Plants Under Operation - 20**  
**Plants Under Construction - 5**  
**Total Rated Capacity - 14800 kCi**



**Products for Processing :**  
**(Medical, Food, Allied Products )**



# Electron Beam accelerator ...ILU-6



# Applications

# Radiation Processing of Foods

**ONE PROCESS**



**Sprout  
Inhibition**

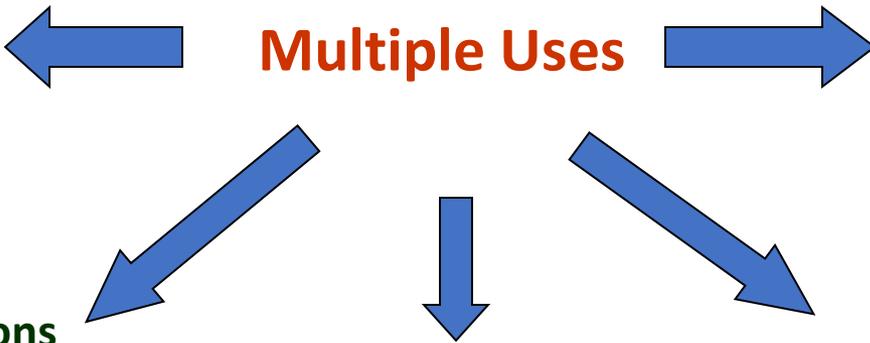
**Onion, Potato,  
Ginger, Garlic**



**Quarantine  
Fruits**



**Multiple Uses**



**Insect Disinfestations**

**Cereals, Pulses,  
Dry Fruits**



**Shelf-life Extension**

**Chicken, Meat, Fish**



**Hygienization**

**Spices**



# Radiation Processing for Non-Food Products

✚ HERBAL & AYURVEDIC PREPARATIONS



✚ CATTLE FEED



✚ DOG / PET FEED



✚ PACKAGING MATERIALS & CONTAINERS



# Disinfestations of cereals and legumes



*Non-Irradiated*

*Irradiated*

# Radiation Processing of Mango



# स्वच्छ भारत Swachh Bharat



# Generation of Sewage and Sludge

- One of the biggest challenges of the high density population is the huge amount of waste water generated directly by self-consumption and indirectly by industries meeting their needs.



❑ 38254 MLD of sewage is produced in cities and towns and 7 million tons per year solid infectious sludge

❑ 133,000 MLD and 24 million tons sludge by 2050

# COMPOSITION OF DRY SEWAGE SLUDGE

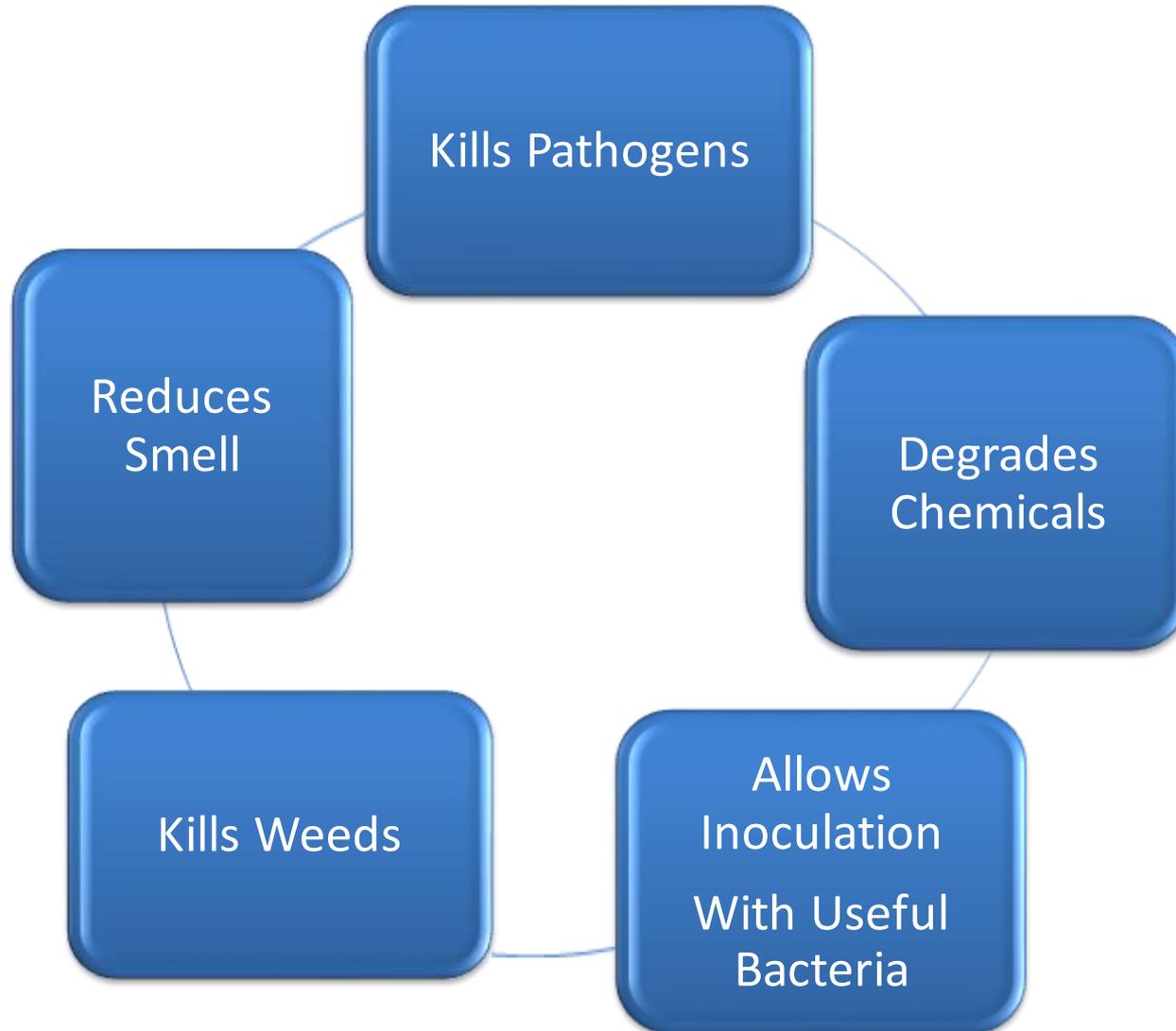
Rich Source of organic carbon(20%-40%) and 3 times more than city compost organic fertilizers

Macro & Micro Nutrients  
N, P, K, Zn, Fe, Cu

Pathogens, Virus,  
Bacteria, Weeds,  
Chemical  
Contaminants

Heavy Toxic Metals  
Lead, Arsenic, Cadmium,  
Chromium etc.

# Radiation Technology Makes Sludge Safer and Useful

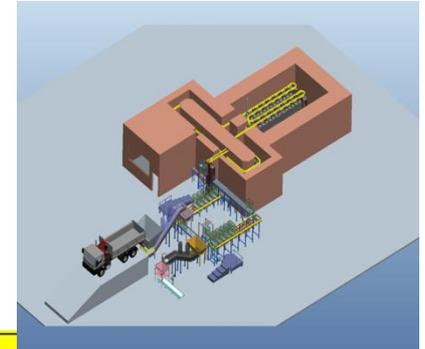
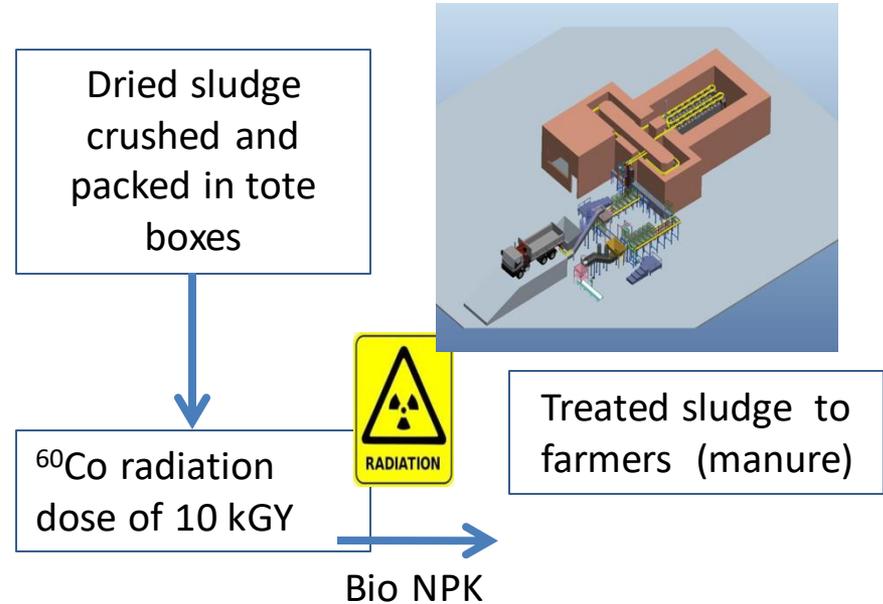


# Radiation Technology For Municipal Sewage Sludge Hygienisation



1<sup>st</sup> facility of 100 tons/day is now operational at Ahmedabad and second at Indore to commence soon.

- ❑ **Total** cost of the project Rs. 30 Crores.
- ❑ **Converts waste sludge to Manure**
- ❑ **Protects health and environment**
- ❑ **Provides organic Carbon to soil**
- ❑ **Saves subsidy on Urea**



Ahmedabad City Sludge Hygienisation Facility October 2017



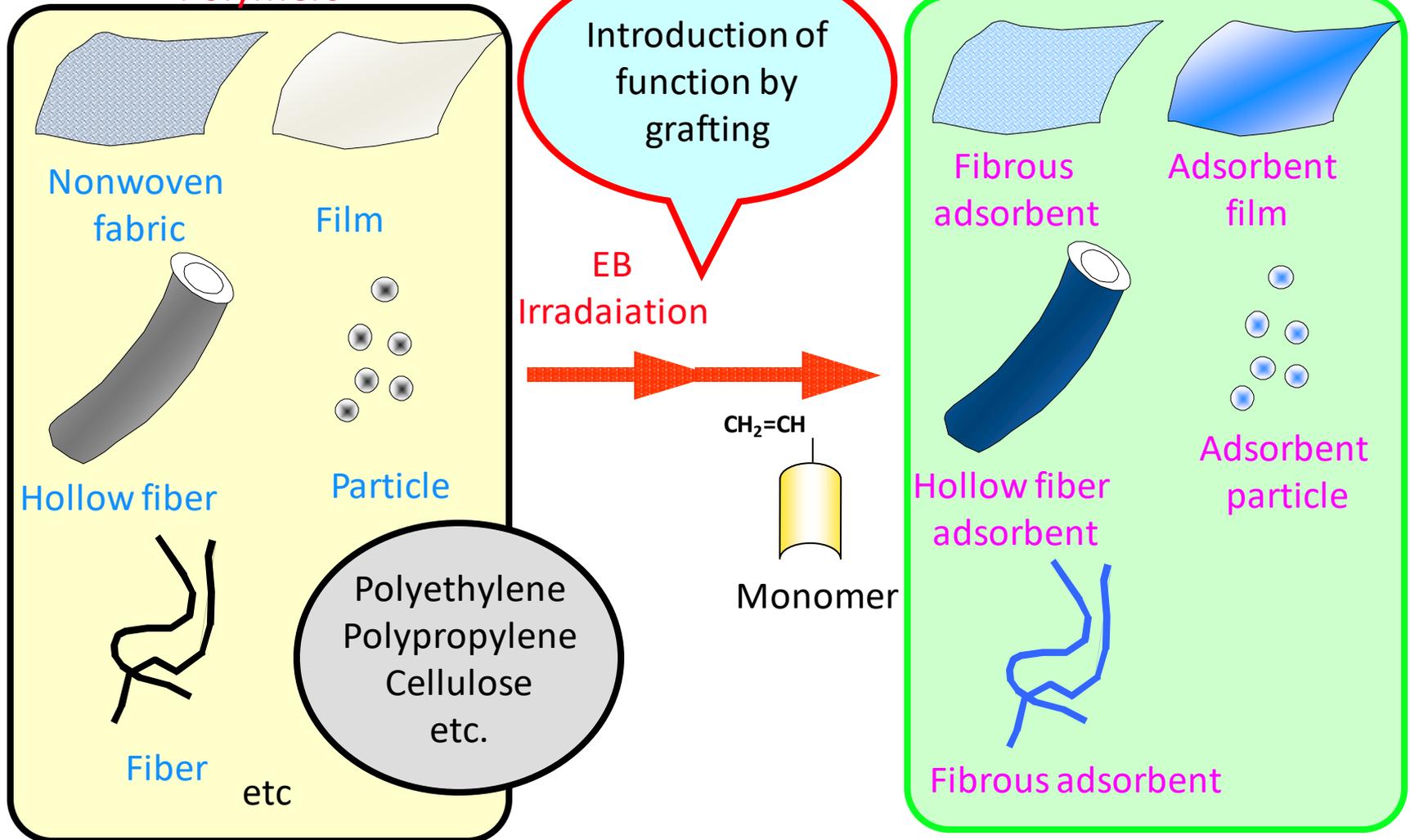
# BIOGOLD



# Advanced Materials for Environment

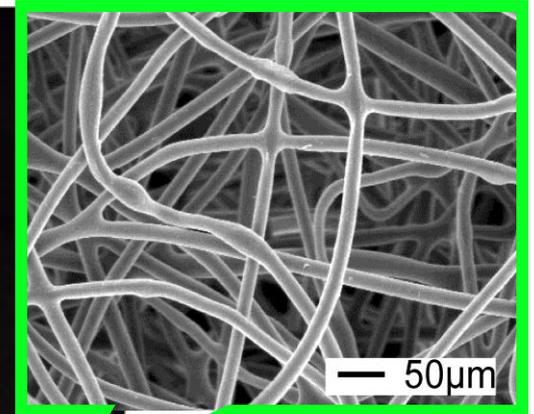
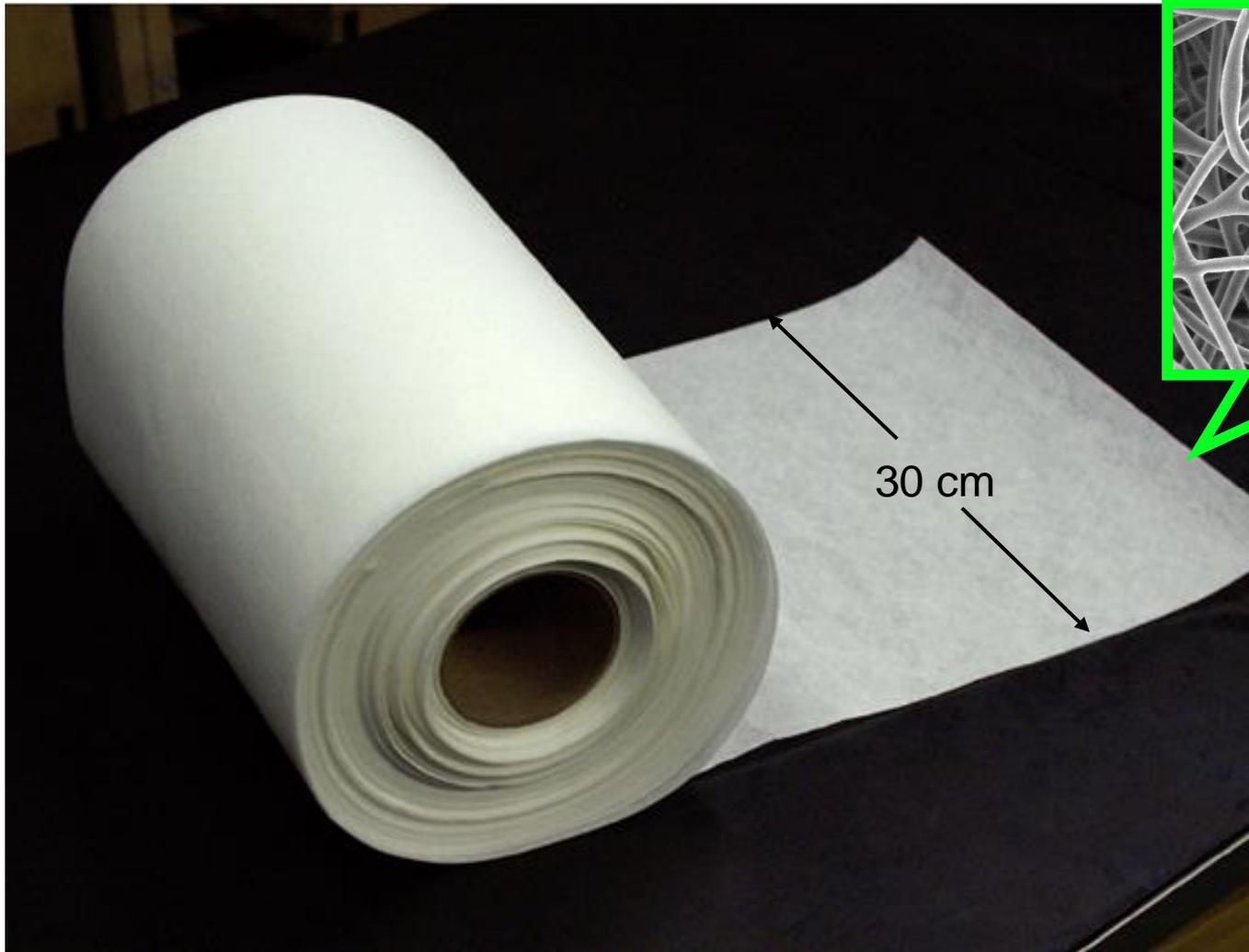
# Trunk Polymers for Graft Polymerization

Variously shaped  
Polymers



Capable of introducing the function of metal adsorption into polymers having various shapes

# Nonwoven fabric (Trunk polymer for grafting)



Synthesis of fibrous adsorbent

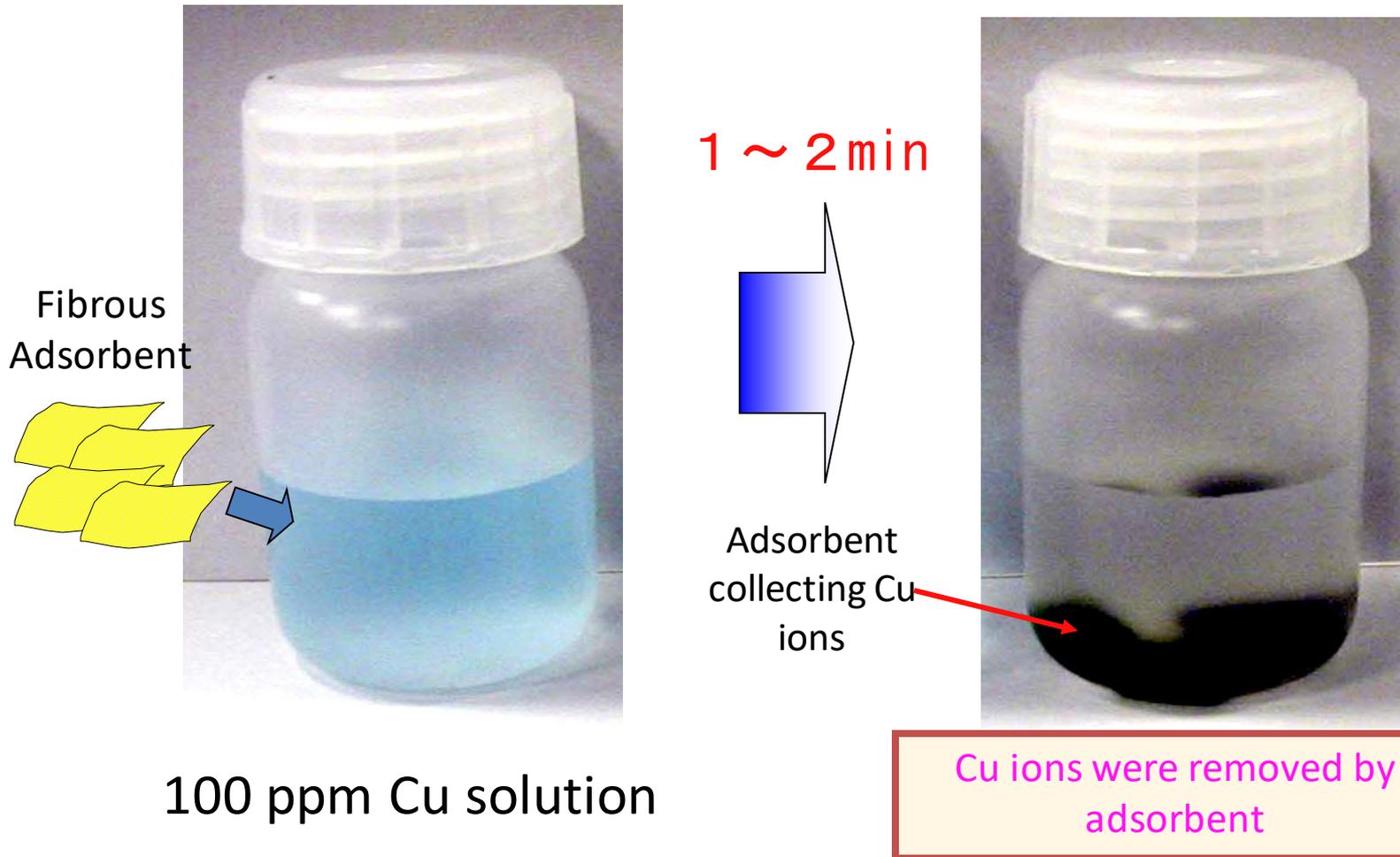


Swift adsorption

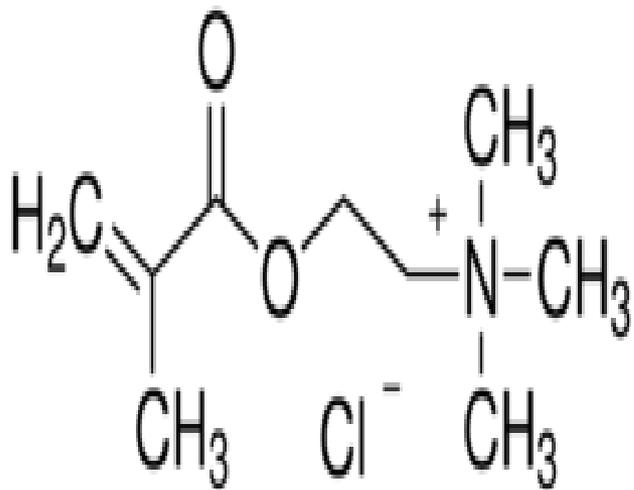
# Chelates and metal selectivity

Chemical structure		Selectivity
Iminodiacetic acid	$\begin{array}{c} \text{CH}_2\text{COOH} \\ \diagup \\ \text{— N} \\ \diagdown \\ \text{CH}_2\text{COOH} \end{array}$	$\text{Hg}^{3+} > \text{Cu}^{2+} > \text{UO}_2^{2+} > \text{Pb}^{2+} > \text{Fe}^{3+} > \text{Al}^{3+} > \text{Cr}^{3+} > \text{Ni}^{2+} > \text{Zn}^{2+} > \text{Ag}^+ > \text{Co}^{2+} > \text{Cd}^{2+} > \text{Fe}^{2+} > \text{Mn}^{2+} > \text{Ba}^{2+} > \text{Ca}^{2+} > \text{Sr}^{3+} > \text{Mg}^{2+} > \text{Na}^+$
Phosphoric acid	$\begin{array}{c} \text{O} \\    \\ \text{— P — OH} \\   \\ \text{OH} \end{array}$	$\text{Th}^{4+} > \text{U}^{4+} > \text{UO}_2^{2+} > \text{Fe}^{3+} > \text{Be}^{2+} > \text{H}^+ > \text{Ag}^+ > \text{Cd}^{2+} > \text{Zn}^{2+} > \text{Cu}^{2+} > \text{Ni}^{2+} > \text{Co}^{2+} > \text{Mn}^{2+} > \text{Ca}^{2+} > \text{Na}^{2+}$
Amidoxime	$\begin{array}{c} \text{— C = NOH} \\   \\ \text{NH}_2 \end{array}$	$\text{Cu}^{2+}, \text{Ru}^{6+}, \text{Au}^{3+}, \text{Rh}^{3+}, \text{V}^{4+}, \text{Pd}^{2+}, \text{U}^{6+}, \text{Pt}^{2+}, \text{Fe}^{3+}, \text{Mo}^{6+}$ (High selectivity) $\text{Cu}^{2+} > \text{Ni}^{2+} > \text{Co}^{2+} > \text{Zn}^{2+} > \text{Mn}^{2+}$
Tiol	$\text{— SH}$	$\text{Ag}^+ > \text{Cu}^+ > \text{Pb}^{2+} > \text{Cd}^{2+} > \text{Zn}^{2+} > \text{Ni}^{2+} > \text{Fe}^{3+} > \text{Ca}^{2+}$
Glucamine	$\begin{array}{c} \text{— NCH}_2(\text{CHOH})_5\text{H} \\   \end{array}$	$\text{BO}_3^{2-}$

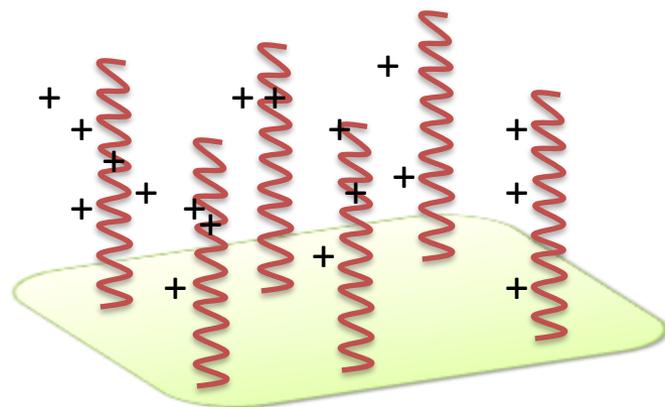
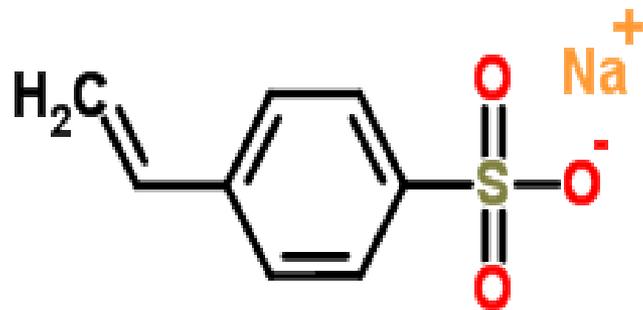
# Toxic metal adsorbent synthesized by radiation-induced grafting



Fibrous Adsorbent: Extremely Rapid adsorption of Metals

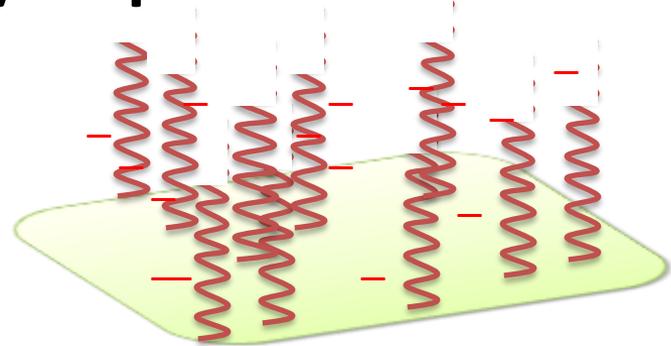


Radiation Grafting  
by Gamma  
Radiation

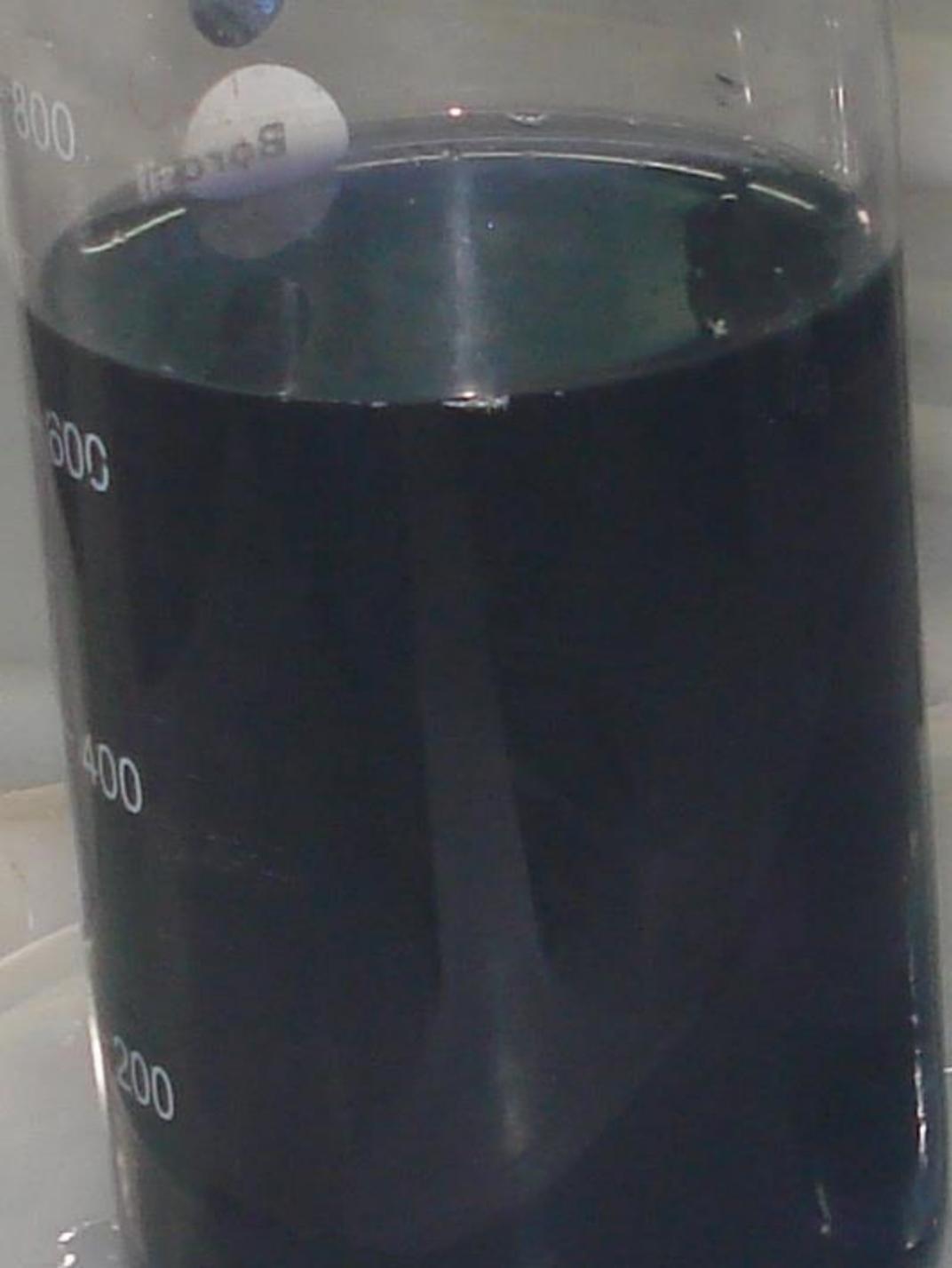


**+tive charged Grafted  
Polymer**

**Hydrophobic and  
Hydrophilic interactions**



**-tive charged Grafted  
Polymer**



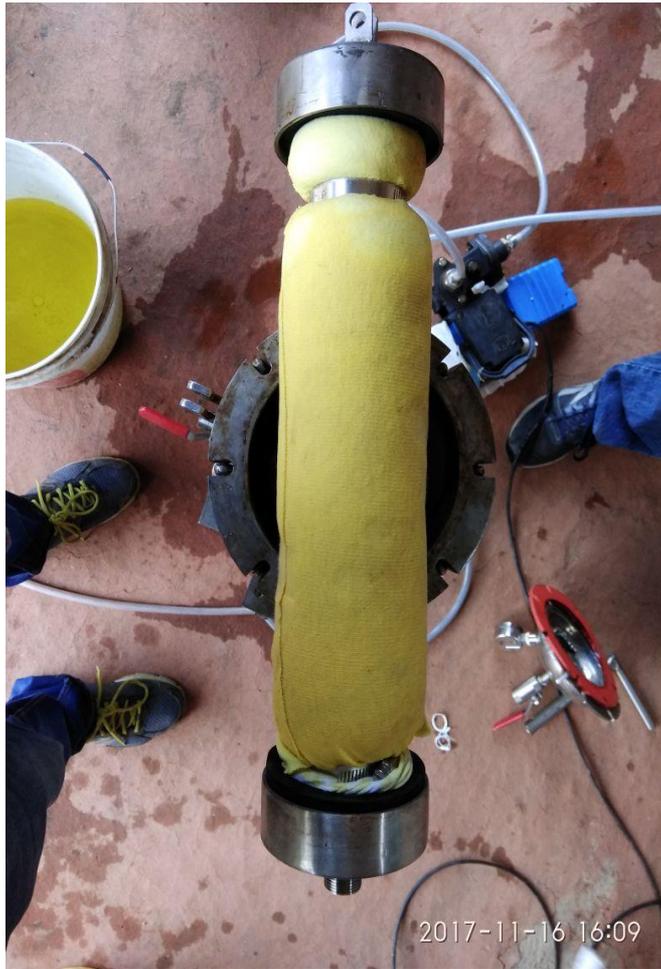
# Textile Dye Effluent Treatment

- 20,000 litres of effluent containing 200 mg/litre dyes can be treated using one kg adsorbent in ten cycles
- Reusable
- Useful for small scale industries (20000-25000 litre/day effluent)
- Machine cost approx. USD 3000

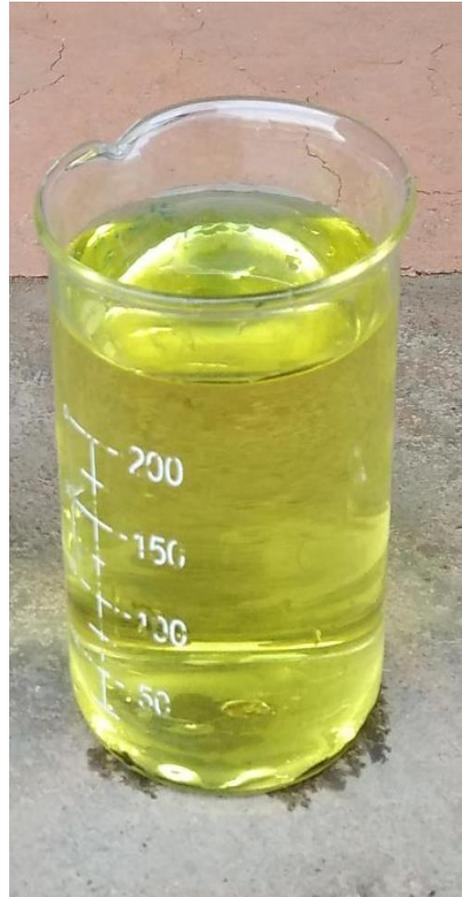




# Column after filtration



# Contaminated water before and after treatment



बोरिंग  
का पानी जिने  
योग्य नही है।





6-Jul-21

TSRP-2012, Mumbai

# Healthcare

# Medical Product Sterilization

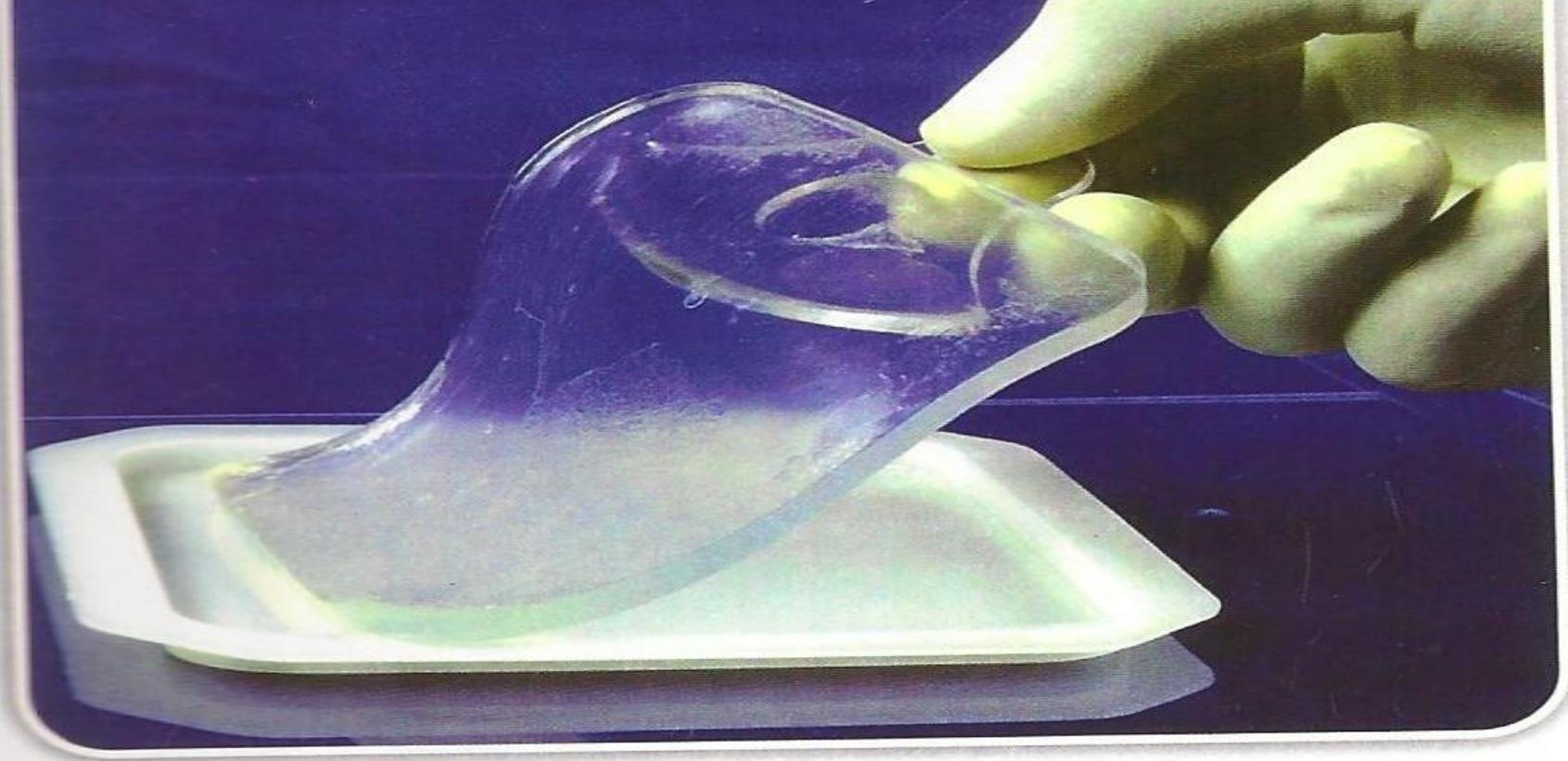


विकिरण प्रसंस्कृत हाइड्रोजेल द्वारा घाव का  
इलाज़

**Radiation Processed Hydrogel  
Wound Dressing**

# BURN CASES ....

- EVERY YEAR THERE ARE MORE THAN 5-7 MILLION REPORTED CASES OF BURN. MORE THAN 500 DIE EVERY DAY. MANY CAN BE SAVED IF TREATED EARLY WITH HYDROGEL DRESSINGS.



# HYDROGELS ARE USED FOR WOUNDS OF

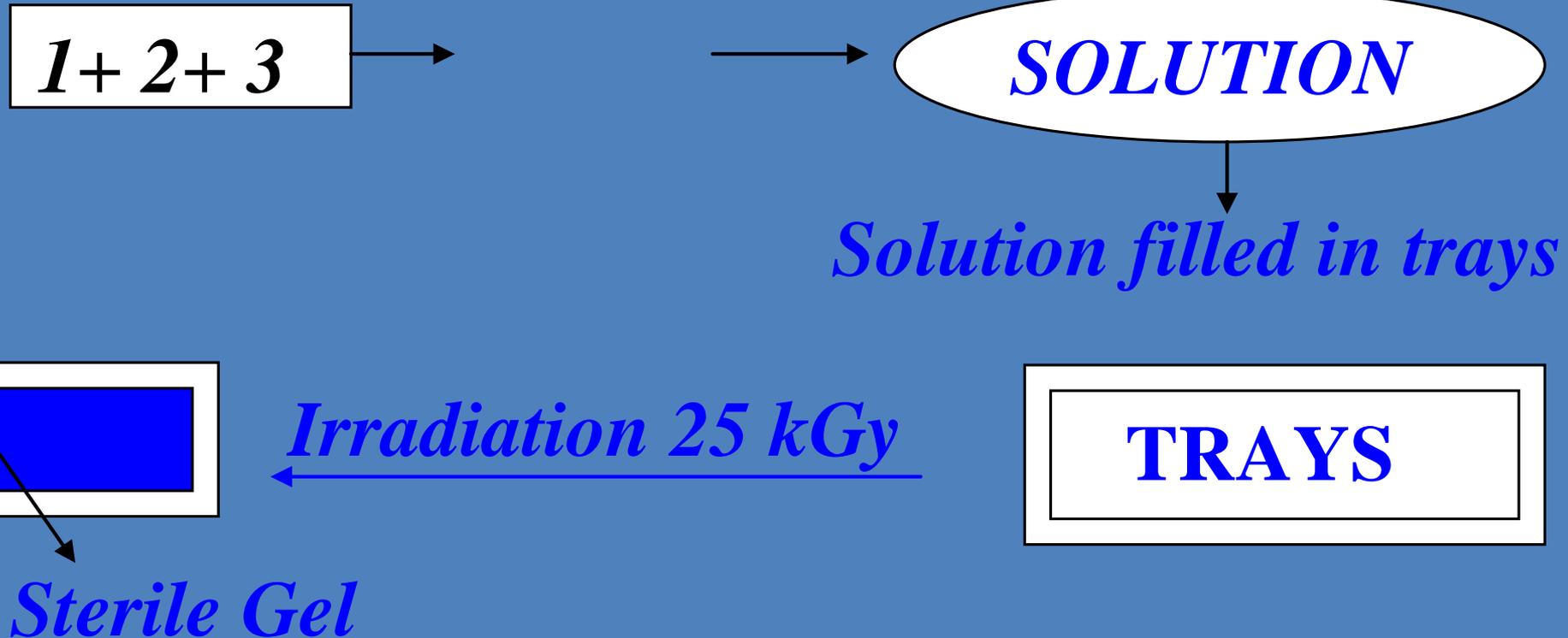
...

- BURNS
- DIABETIC ULCERS
- LEPROSY ULCERS
- BED SORES
- SUN BURNS
- ANIMAL BITES
- DONOR AREAS IN PLASTIC SURGERY
- CANCER TREATMENT

# BURN DRESSING

## INGREDIENTS:

1. POLYVINYL ALCOHOL
2. NATURAL POLYSACCHARIDES LIKE AGAR
3. DISTILLED WATER



# IODINE- HYDROGEL



- IODINE FORMS COMPLEX WITH [Hydrogel](#) [Movie.wmv](#) PVA AND IS RELEASED TO THE WOUND IN SUSTAINED MANNER. THIS GIVES BEST PROPERTIES OF HYDROGEL AND IODINE.

# Technology Transfer in India



**Hizel**<sup>™</sup>

**Sterile Hydrogel Surgical Dressing**  
Sterilized by Gamma Radiation

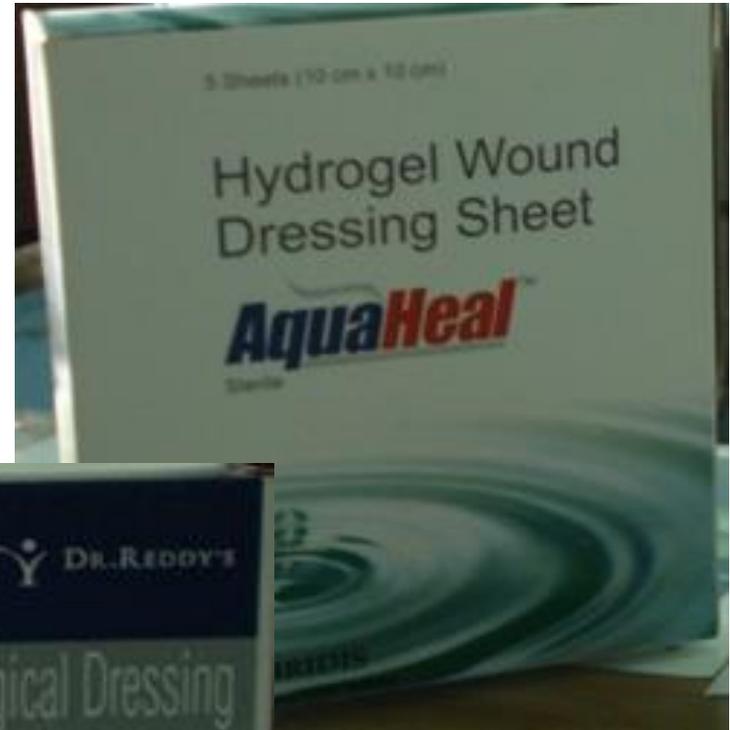
**The 1st choice in**

- 1st and 2nd degree burns
- Diabetic, Trophic and Non-healing ulcers
- Bedsore
- Donor area
- Sunburns and Abrasions
- Leprosy ulcers

**Healing on FAST TRACK**

Manufactured under license from  
BOARD OF RADIATION & ISOTOPE TECHNOLOGY  
DEPARTMENT OF ATOMIC ENERGY, GOVERNMENT OF INDIA

Manufactured by  
**ABS MEDIC**  
201-A, Ushakiran  
Fax: 2333728, E-mail: [abs@absmedic.com](mailto:abs@absmedic.com)



3 Sheets (12 cm x 12 cm)

Hydrogel Wound Dressing Sheet

**AquaHeal**<sup>™</sup>

DR. REDDY'S

**Sterile Hydrogel Surgical Dressing**  
(Sterilized by Gamma Radiation)

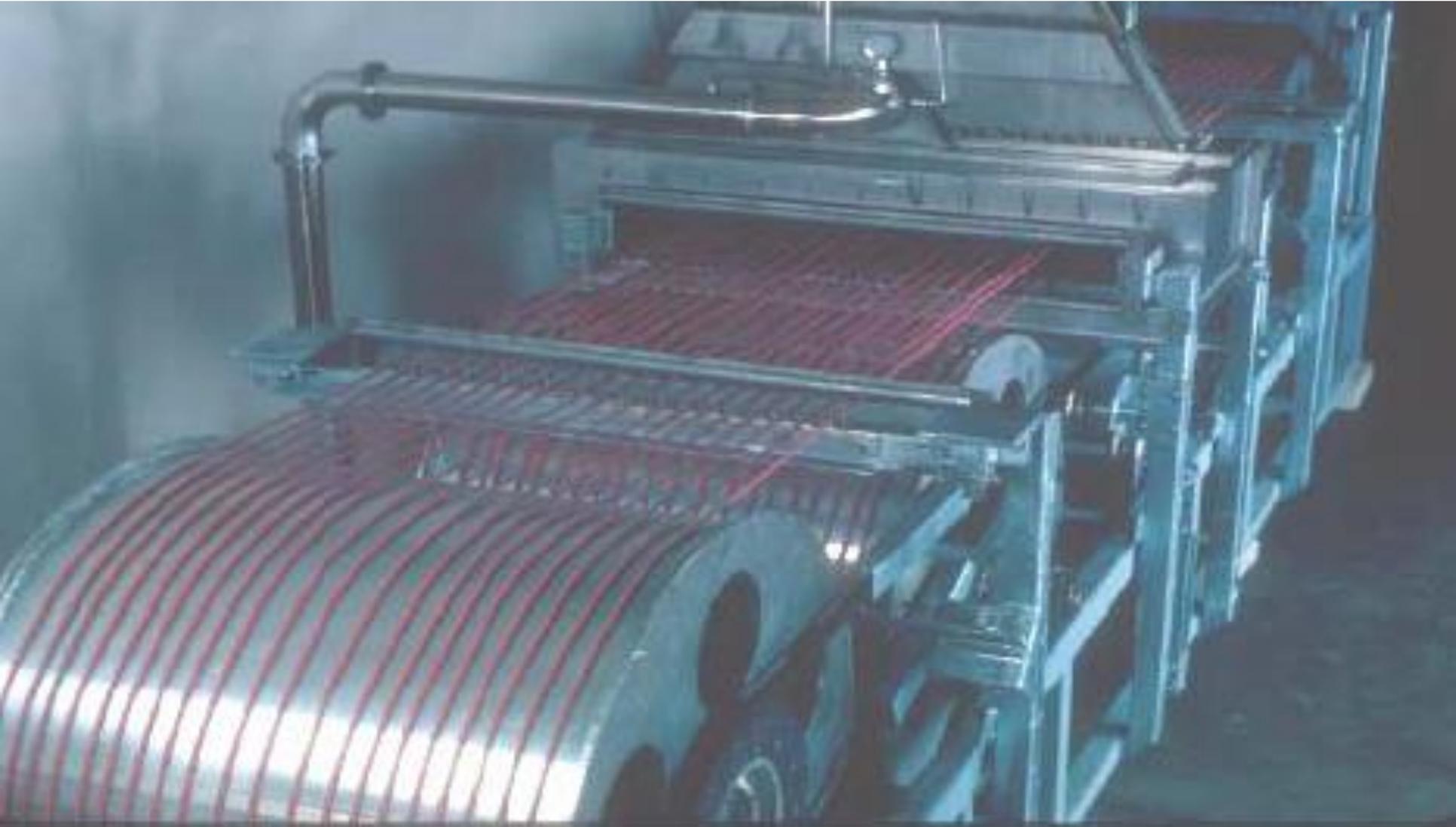
**Hydroheal**<sup>™</sup>

3 Sheets (12 cm x 12 cm)



# Industry

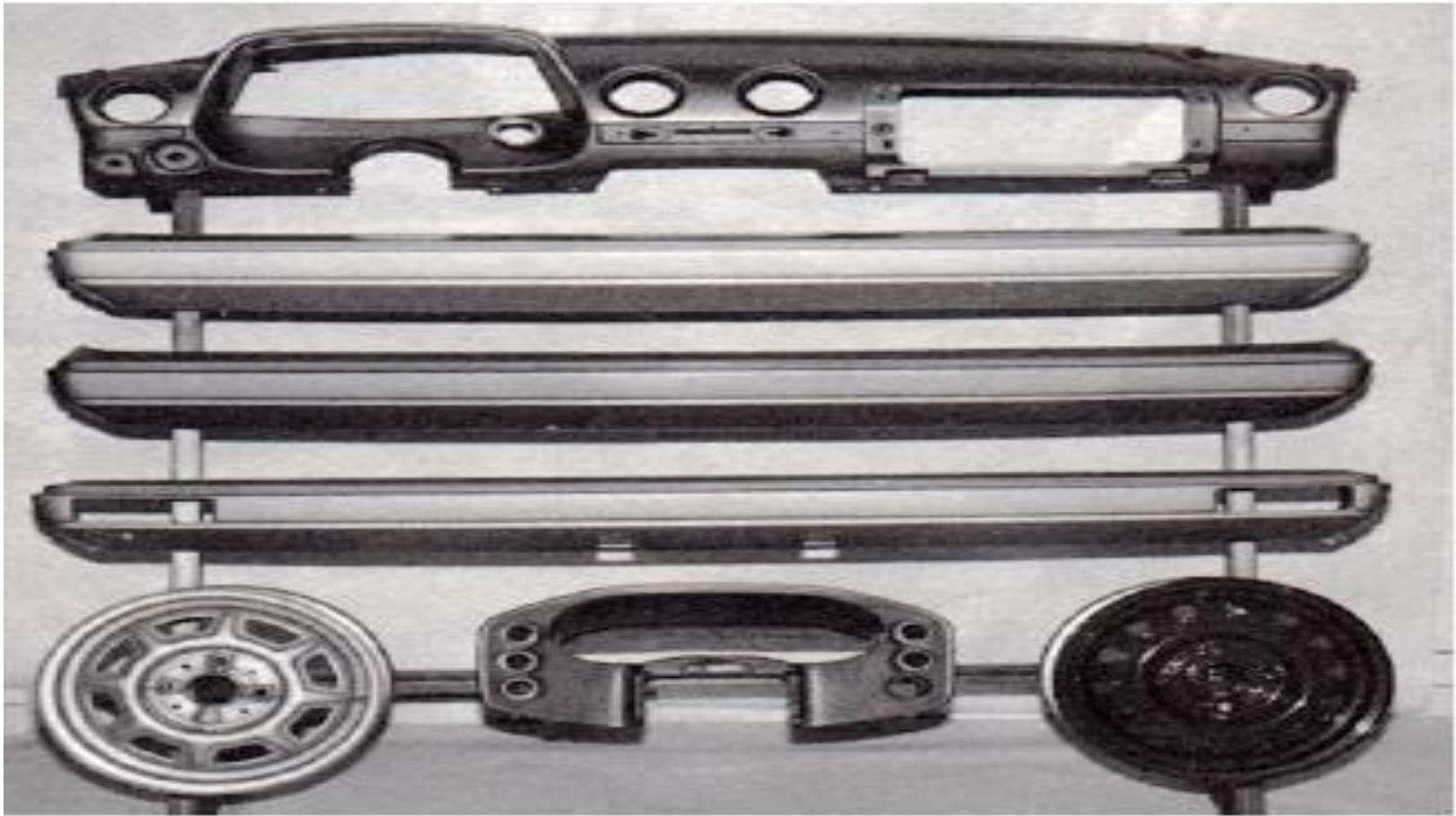
# E. Beam Wires and Cable Irradiation



# EB Crosslinked Flame Retardant Insulation

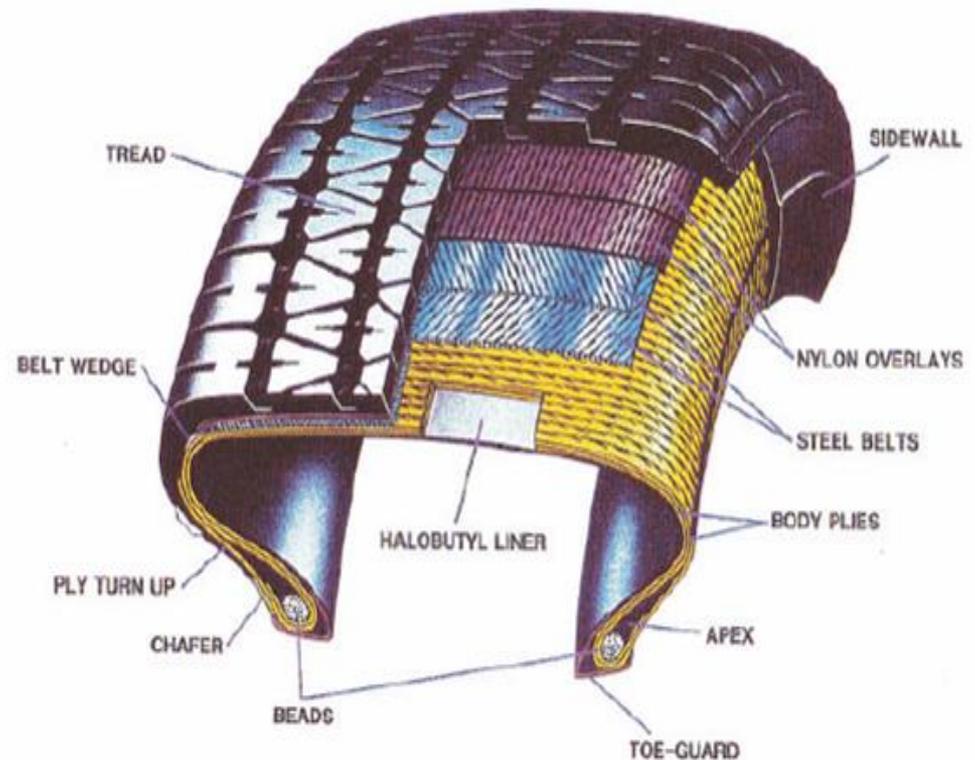


# EB Cured Autoparts



# EB processing of Automobile Tyres

- Pre-curing of tyre components using EB results in retaining shape, dimensions during tyre building, construction and vulcanization
- Improved green strength, better endurance & abrasion characteristics
- Less scrap
- Curing time reduced by 20% - leads to throughput increase
- One EB plant is operating in Mysore for this application



How can one join Department of  
Atomic Energy as Scientist?

# When Radiation Technology Helps Common Man

**ATOMS SMILE**

Thank you for your kind attention

