Textile Dye Effluents Treatment by Radiation Technology

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Textile dyeing industries present in India

- **Textiles account for 14% of India's industrial production ~27% of its export earnings**
- **~10,000 garment manufacturers and 2200 bleaching and dyeing industries in India**
  - **Kolhapur, Maharashtra**
  - **Erode and Tirupur district, Tamilnadu**
  - **Surat, Gujarat**
  - **Ludhiana, Punjab**
  - **Jaipur, Rajasthan**

Effluents are generated from textile dyeing industries

pH adjustment

Effluents are Sent to ETP

Schematic of effluent treatment plant (ETP)

pH adjustment

Effluents → Collector → Equalization tank

Equalization tank → Primary treatment Coagulation, 50-65 %, reduction

Primary treatment → Liquid goes to settling tank → Secondary treatment Biological

Secondary treatment Biological → Effluents are discharged

Primary treatment → Sludge is separated and dumping of sludge

Fixation of dyes on its fiber

DYE CLASS	DEGREE OF FIXATION (%)	LOSS TO EFFLUENT (%)
Acid	80-95	5-20
Basic	95-100	0-5
Direct	70-95	5-30
Disperse	90-100	0-10
Metal-complex	90-98	2-10
Reactive	50-90	10-50
Sulfur	60-90	10-40

Parameters of effluent before treatment

Parameters	Concentration (ppm)
COD	900-1000
BOD_5	400
pH	10-11
Suspended Solids	120-268
Dissolved Solids	7000
Sulphate	5000
Oil and Grease	10

Discharge Limit of Textile effluent set by Central Pollution Control Board

Parameters	Concentration (ppm)
COD	≤250
BOD_5	30
pH	7 – 10
Suspended Solids	100
Dissolved Solids	2100
Sulphate	1000
Oil and Grease	10

COD = Chemical Oxygen Demand
BOD_5 = Biochemical Oxygen Demand

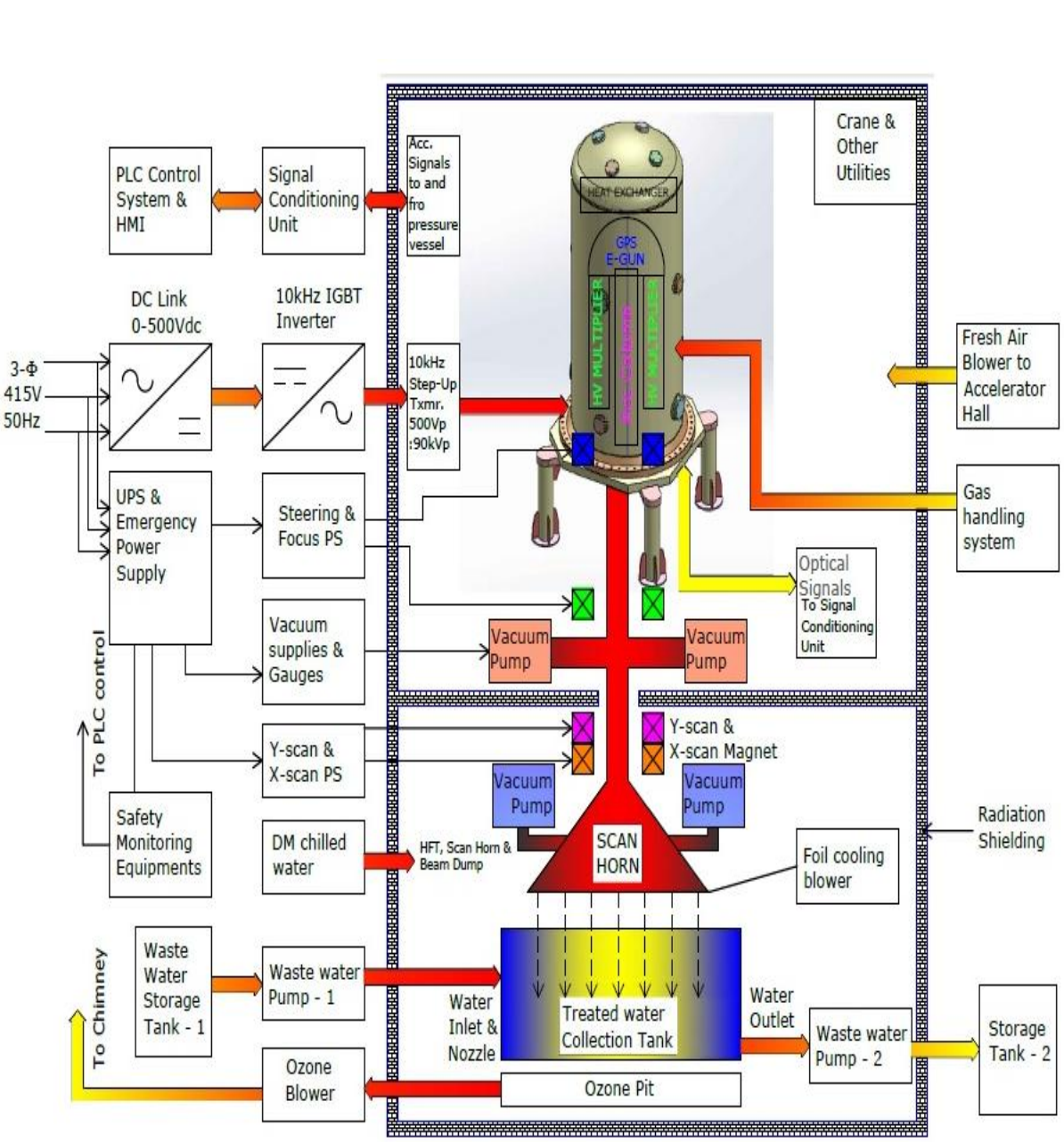
Degradation of Textile Dye Effluents by 1 MeV/10 kW Electron Beam Accelerator at EBC, Kharghar

Development of Electron Accelerators at EBC

TECHNOLOGIES FOR NEW INDIA@75
आज़ादी का अमृत महोत्सव

Beam Technology Development Group, BARC, Mumbai

Schematic of DC Electron Accelerators

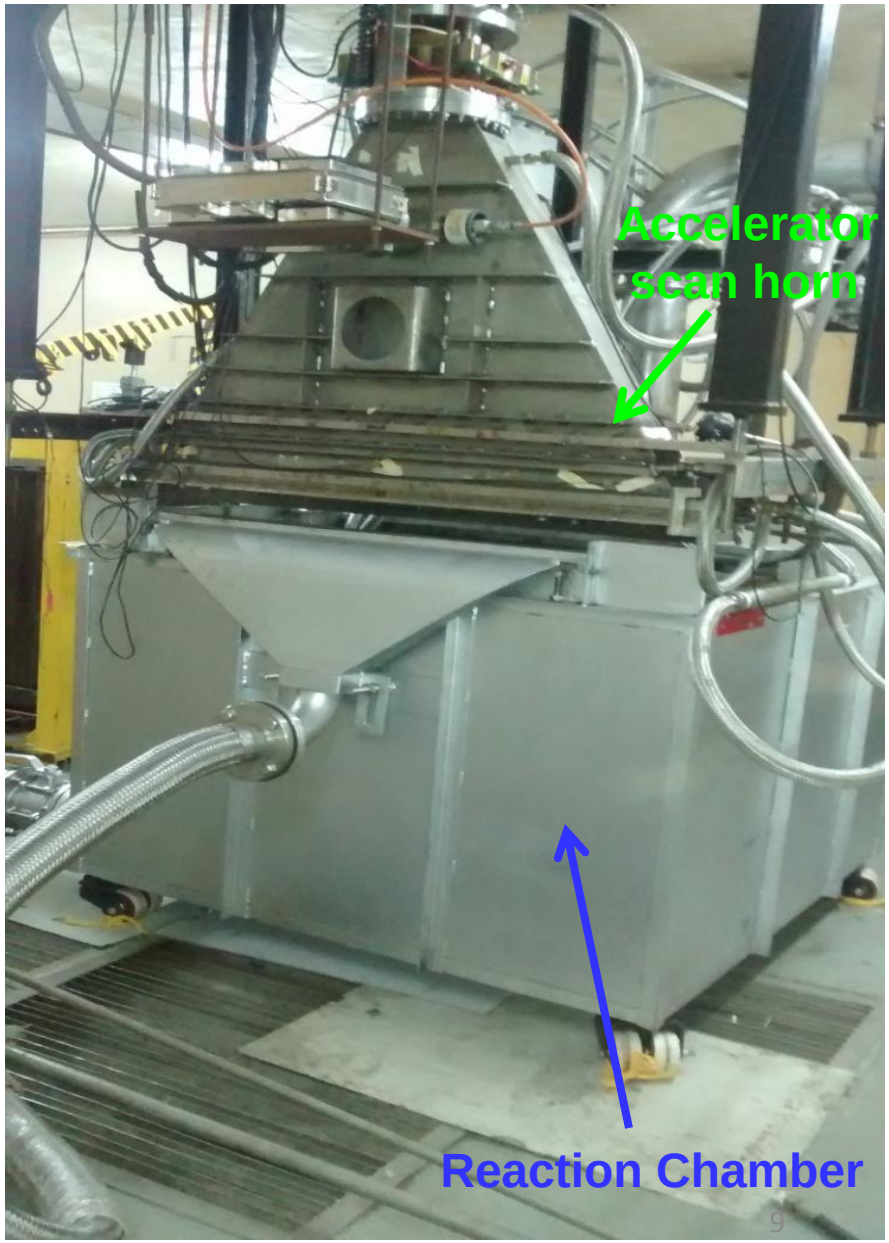


Technical specifications of Accelerator

- Beam Energy : 800 - 1000 keV
- Beam current : 0 - 100 mA
- Beam Power : 100 kW (max.)
- Mode of operation : DC
- Particle of acceleration : Electrons
- Size of Beam scan : 1.5 meters x 100mm
- Depth of penetration : 4mm (for unit density)
- Expected dose : 3 - 5 kGy

Waste Water Treatment Facility at EBC

- **Waste Water: Industrial Grade (Azodye) 10,000 L**
- **Water Feed System: 600 lpm to reduce BOD and COD**
- **Target: To treat 2 MLD water**



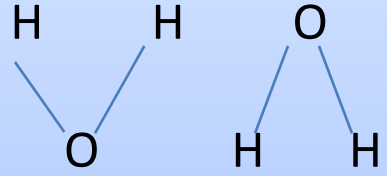
Experiments on RR Red 120 dye in aqueous solution

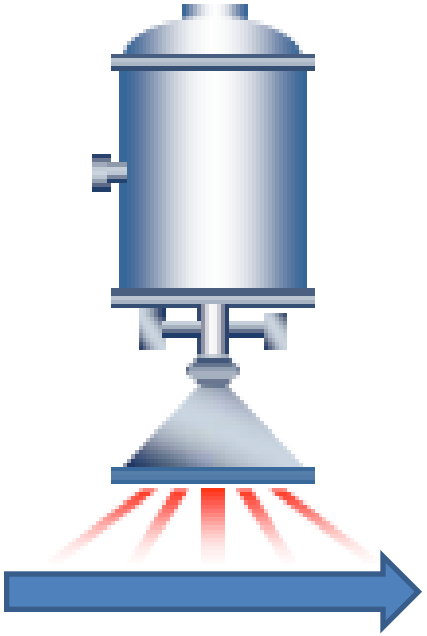
Jhimli Paul Guin , Lalit Varshney

Electron beam treatment of waste water

Substrates

Organic material +
Dyes+ solids+ parasites+
Inorganic compounds +
Heavy metals +





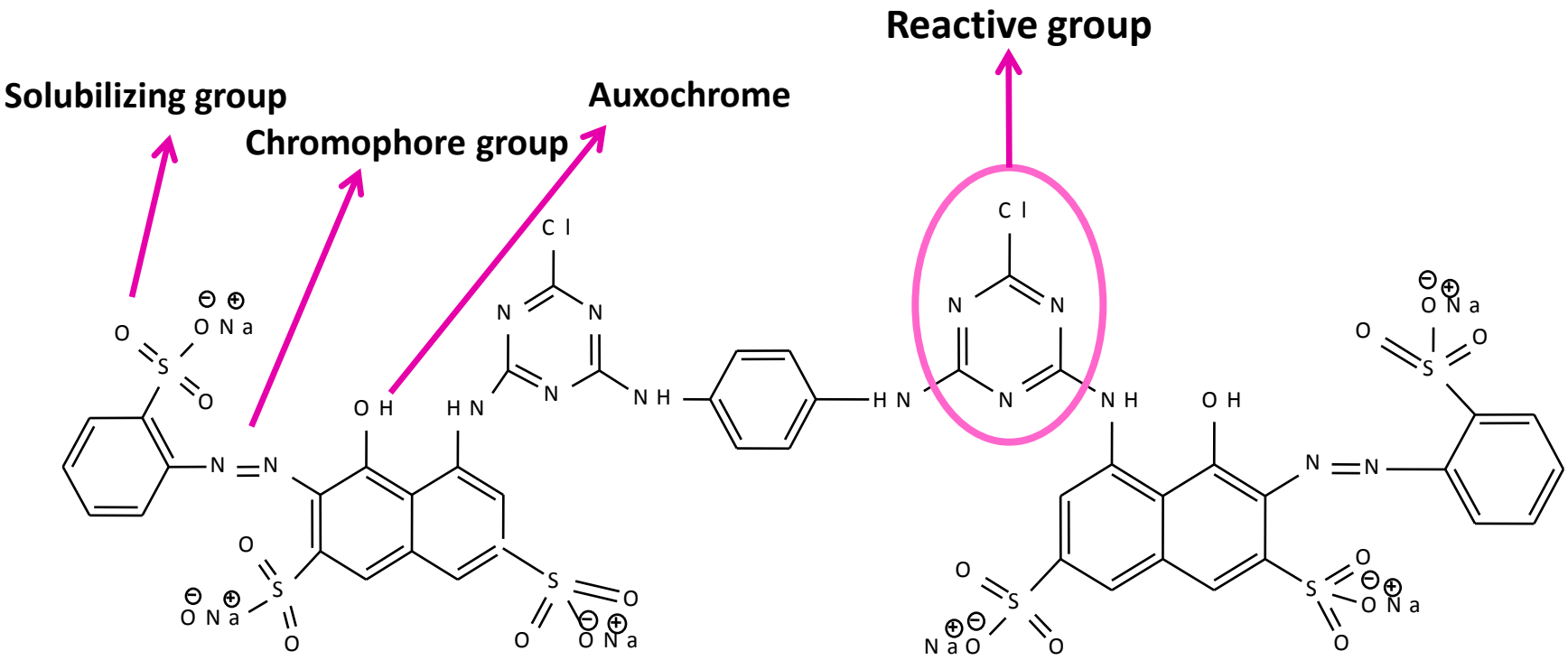
OH, H, H_2O_2, e^-_{aq}

Products

Complete decomposition
$CO_2 + H_2O$
Partial decomposition
Transformation products+
Toxic groups+
Removal recidues+ suspended solids

$$H_2O \xrightarrow{EB} e^-_{aq}, {}^{\bullet}H, {}^{\bullet}OH, HO_2^{\bullet}, H_2O_2, H_2$$

Structural features of reactive dyes

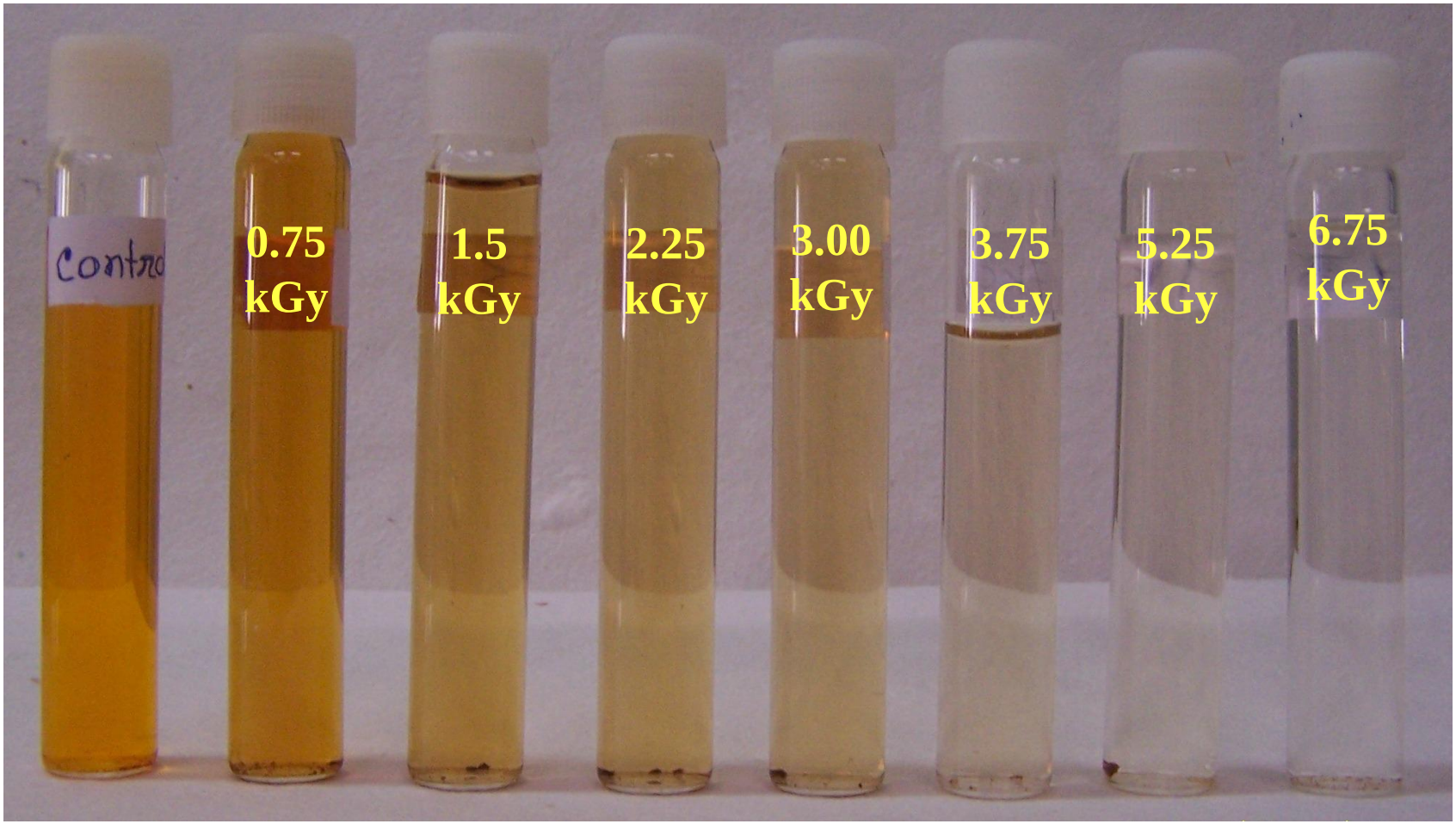


Reactive red 120

Experimental Parameters
Simulation Studies

Dye = Acid Orange
Concentration of dye = 120 ppm
Volume of dye solution treated = 10,000 L
Electron beam energy = 1.2 MeV
Power of the beam = 10 kW
Flow rate of the dye solution = 600 L/Min.

Camera picture of the irradiated dye solutions



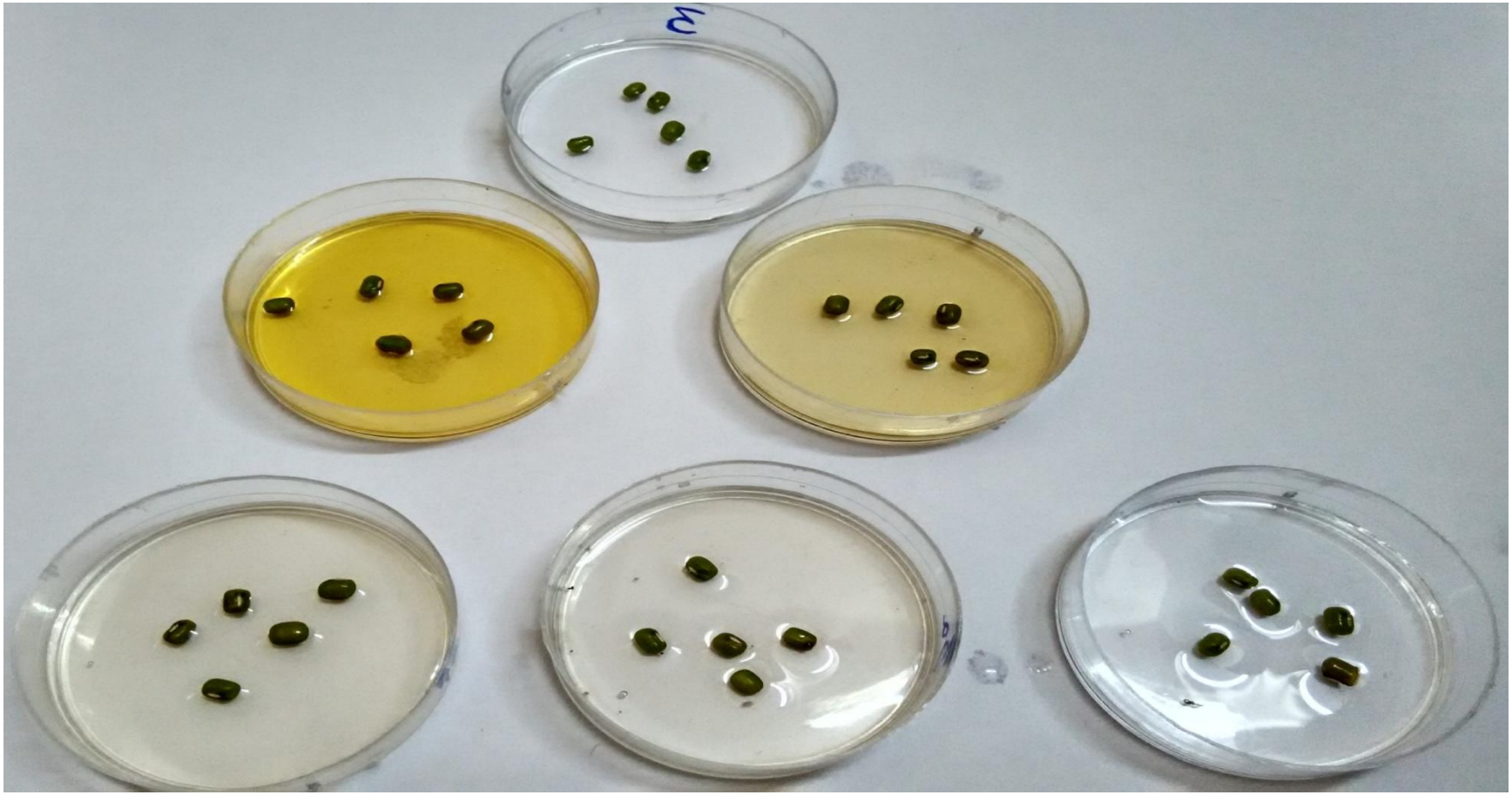
Electron beam treatment of Reactive Red 120 aqueous dye solution

Biodegradability study

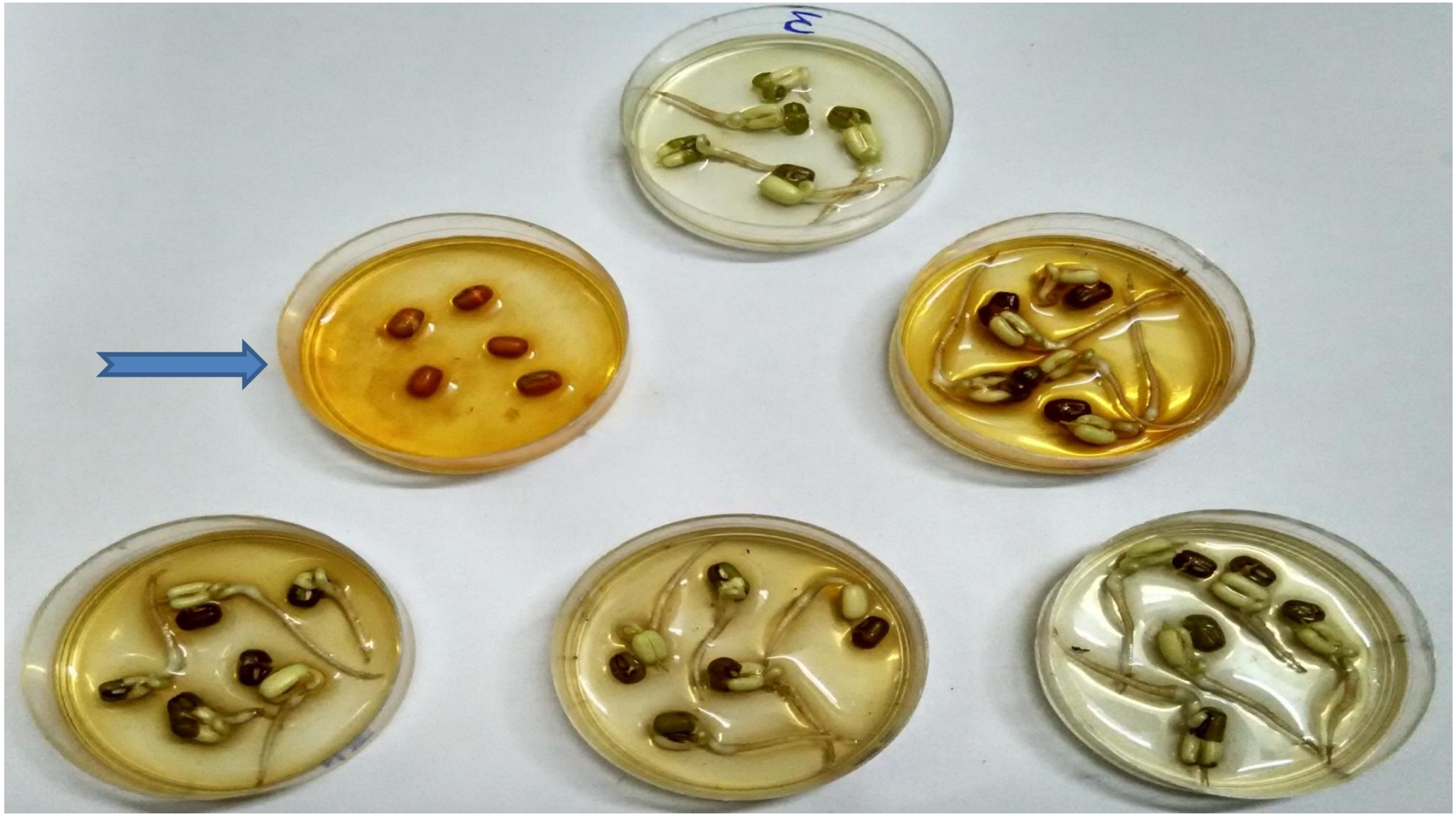
% BOD and BOD_5/COD ratio of aqueous solution of RR-120 at different doses at different dye concentrations

Dose (kGy)	Concentration of RR-120 : 147 ppm		Concentration of RR-120 : 191 ppm	
	Increase of BOD_5 (%)	BOD_5/COD	Increase of BOD_5 (%)	BOD_5/COD
0.0	00.00	0.20	00.00	0.17
1.5	16.18	0.30	15.38	0.23
2.5	35.26	0.34	41.21	0.28
5.0	42.77	0.37	56.60	0.32
10.0	50.23	0.56	60.23	0.37

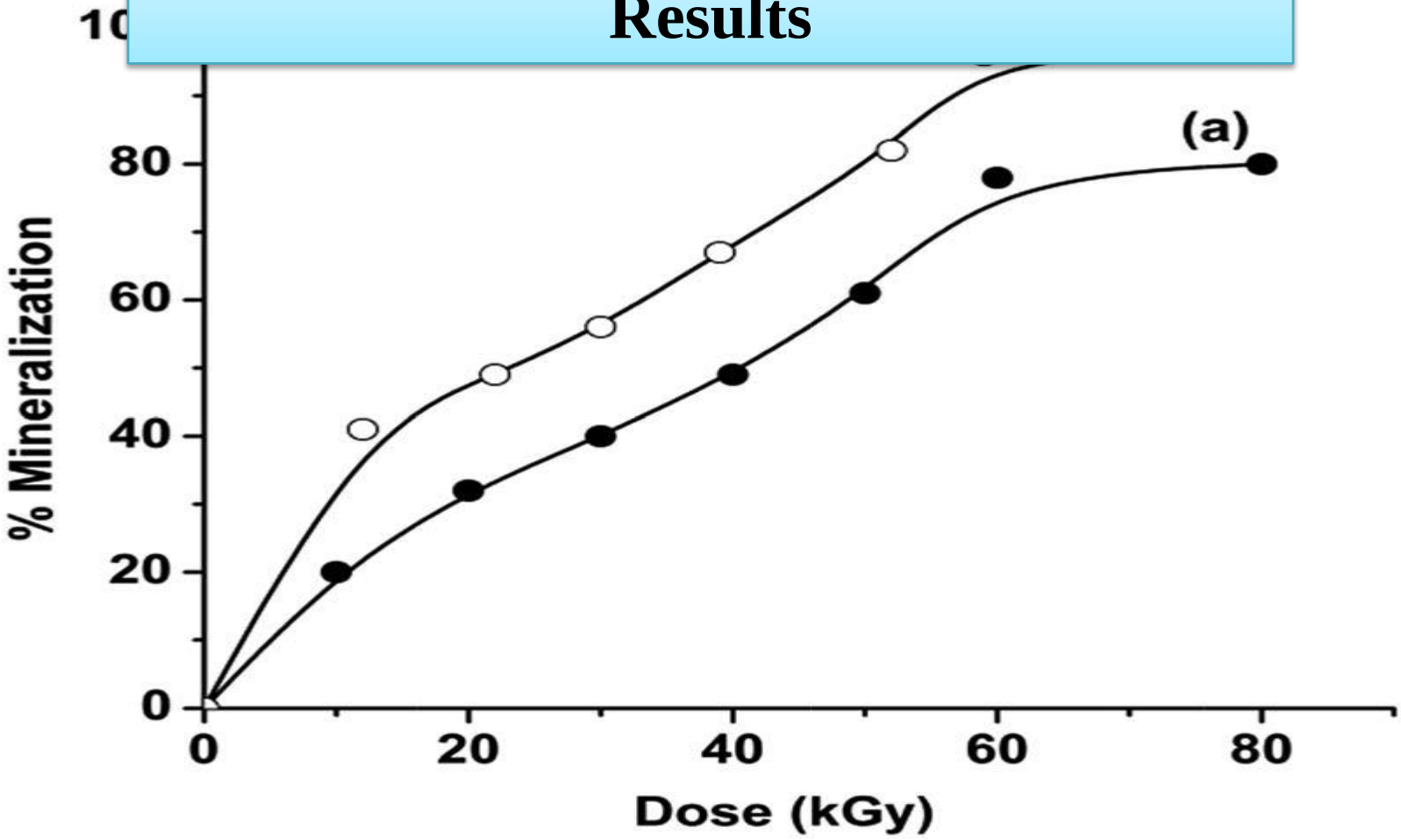
Sprouting of Moong Seeds



Sprouting of Moong Seeds after Two Days



Synthetic Waste Water Treatment Results



Mineralization of WW in the presence of $4X10^{-2}$ mol dm^{-3} $K_2S_2O_8$ during (a) gamma radiolysis, and (b) EB radiolysis* [SW=Reactive red 70 +Sodium Dibenzyl Sulphonate 375 +EDTA 150+Na2Co3 4876, +NaOH 188 + NaCl 10000 ppm]

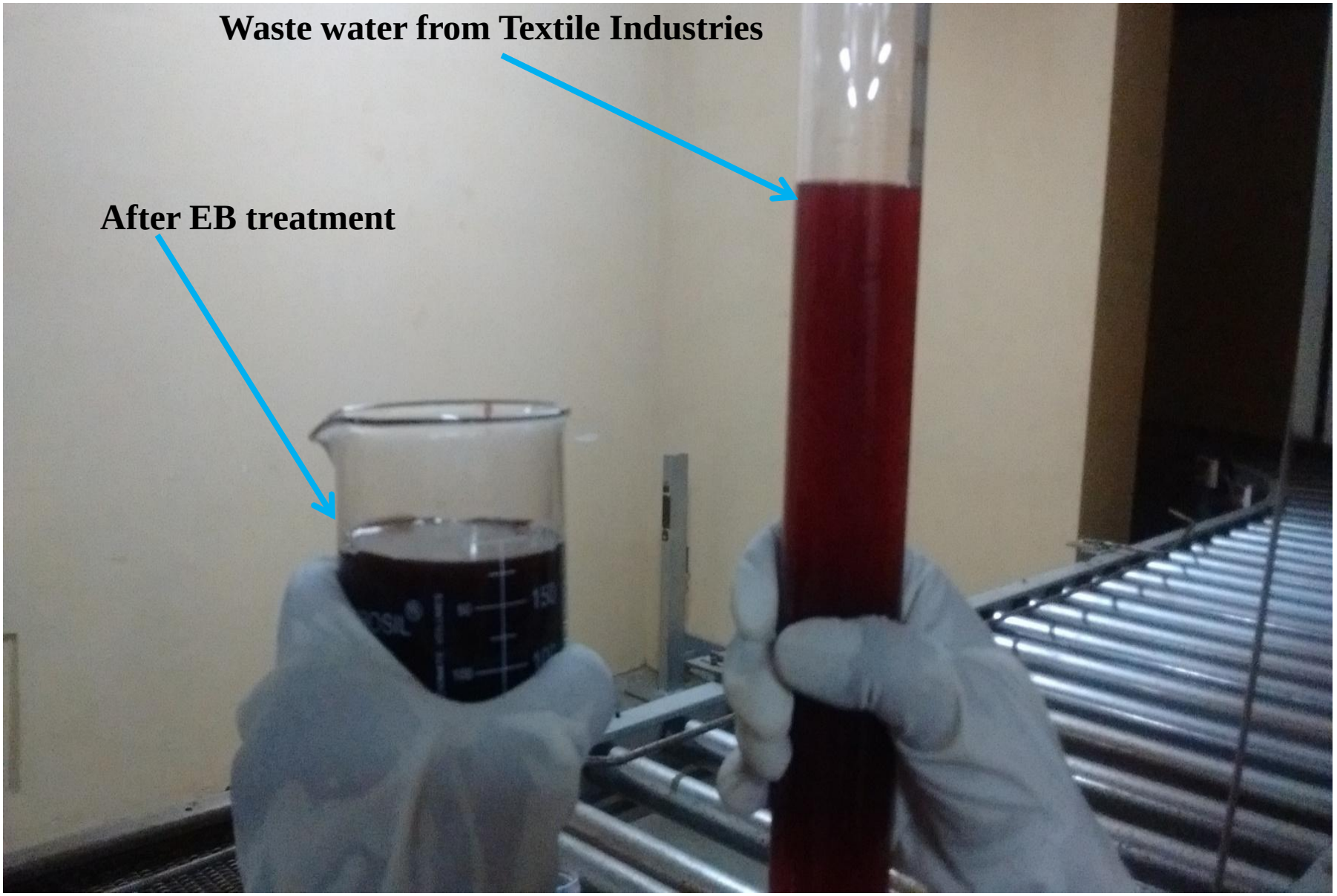
***Jhimli Paul Guin *et al*, RSC Adv., 2014, 4, 53921**

Textile Dye Effluent from CETP

Effluent from Textile industry(No biological or chemical treatment, e.g. Wash Cycle)

Treatment (Dose, kGy)	pH	TDS	COD	OD(621 nm)
0	8	4200	299	0.240
5	8.7	3820	180	0.178
10	8.8	3880	171	0.160
15	8.7	3840	156	0.179
20	8.6	3870	165	0.165
Ozonated, 1 mg/ml 5kGy	8.6	3840	280	0.001

CETP Waste Water Treatment at EBC



Textile Dye Effluent Treatment 2022 (China)

Machine / Application

- Energy 1-2 MeV
- 60-100 mA
- Dose 1 kGy
- 7 Accelerators
- 30 MLD/day dye effluent

Process Steps

1 .Effluent COD 500-700
2. Chemical and Biological Process--→ COD 180-280
3. Electron Beam Treatment @ 1 kGy, COD 15-20
4. Reverse Osmosis
5. Reuse

Slizong Wang et. al., Radiation Physics and Chemistry, 196(2022)110136

Electron Beam Treatment is effective on Lean Effluents(Lower COD,TSS, TDS). Chemical and Biological Pre Treatment would help Electron Beam Treatment with an added advantage of disinfection.

Tannery Effluent Parameters

Parameter	Inlet Values	Standard
pH	6.5-9.5	-
BOD	1000 – 1800 mg/l	30 mg/ml
COD	2000 – 4000 mg/l	250 mg/ml
TSS	2000 - 3000 mg/l	-
Toal Chromium	40—100 ppm	1.0 mg/ml
TDS	5000-10000 mg/l	-

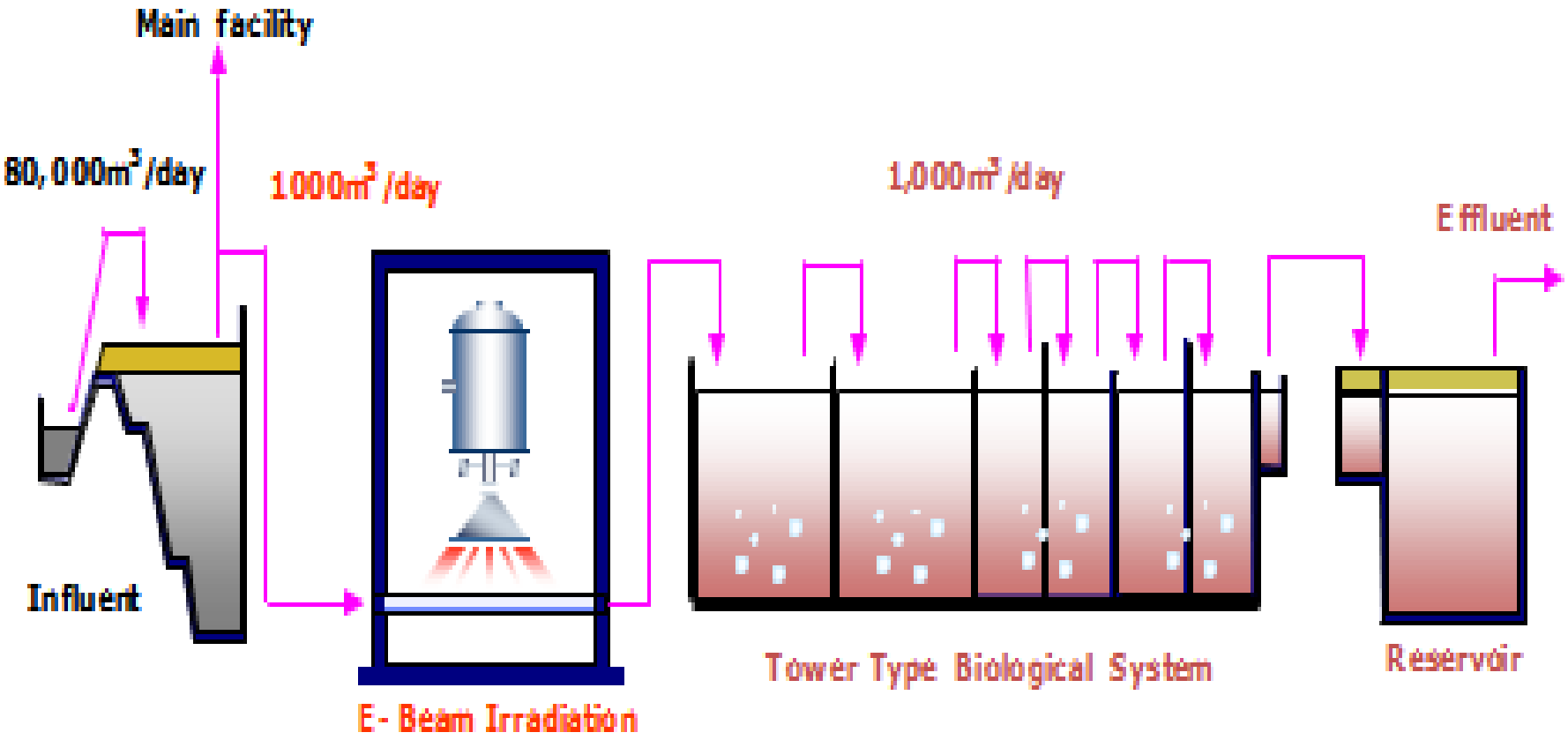
Effluent from Leather industry(No biological or chemical treatment)

Treatment (Dose, kGy)	pH	TDS	COD	Chromium
0	4.2	21862	`1792	384
0	6.9	21862	1792	332
5	6.5	21680	1600	34
10	6.4	21607	1744	27
20	3.9	-	-	406
20	6.8	-	-	34

Tannery Effluent Parameters

- It is important to know what are the contributors for COD in the effluent. E Beam treatment may not be effective at all in certain cases.

A typical Electron Beam treatment process at Effluent treatment Facility [In our experiments we observed 15-17% increase in Biological degradation an 5 kGy]



Proposed Scheme for textile Effluents[Radiation dose division]

- Lower sludge generation
- Higher discolouration
- Higher COD reduction
- Lower Load on RO system for reuse

Same accelerator to be used after different treatment cycle.

Conclusions

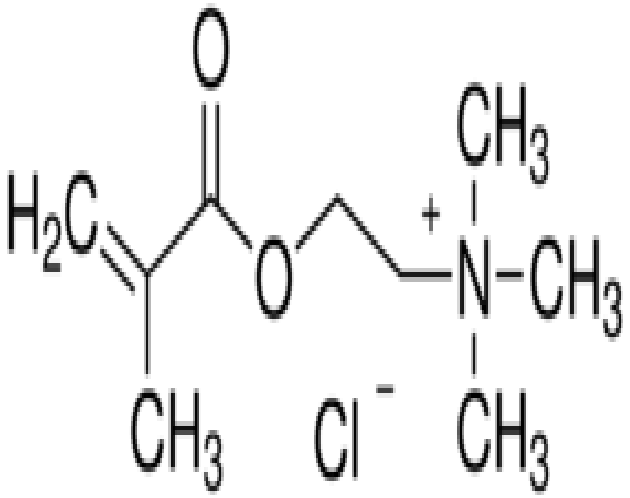
- Effective in treating lean effluents and therefore very useful for wash cycle water(80%) instead of effluents from CETP.
- Need to be combined with other methods like Chemical and Biological Treatment for treating CETP effluents

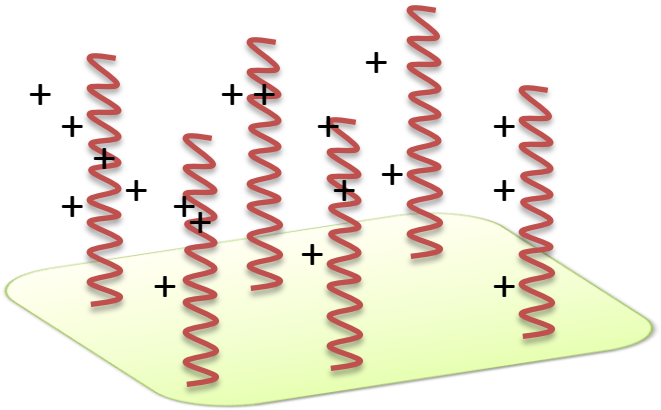
Conclusions

- Large investment required and industry hesitant to adopt as cost of treatment per kilolitre is much higher than conventional methods.
- Industry under pressure due to zero discharge policy and scarce water. Looking for better and economic solutions.

Radiation Grafted Cotton
"A Wonderful Material"

1. Removes dyes from lean effluent
2. Removes Arsenic from ground water
3. Removes Chromium from ground water
4. Antibacterial
5. Low capital investment cost
6. Technology transferred to few companies

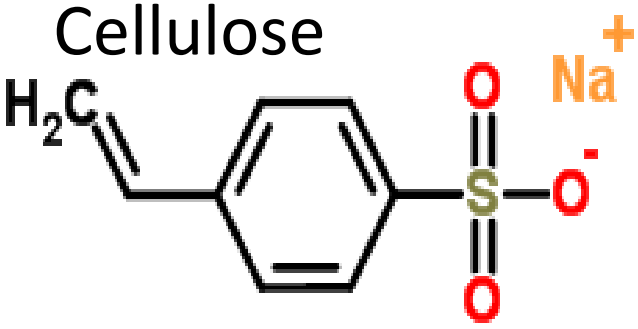


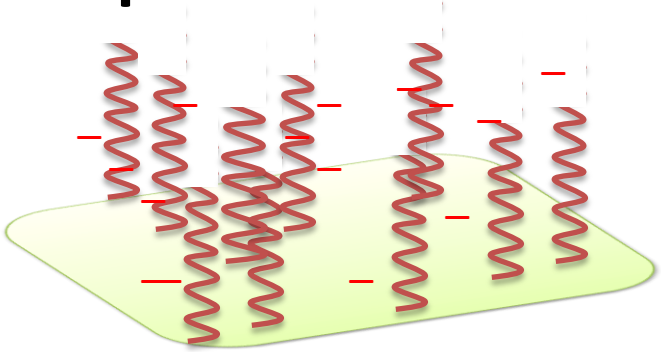


+tive charged Grafted Polymer

Radiation Grafting by Gamma Radiation on Cellulose

Hydrophobic and Hydrophilic interactions





-tive charged Grafted Polymer

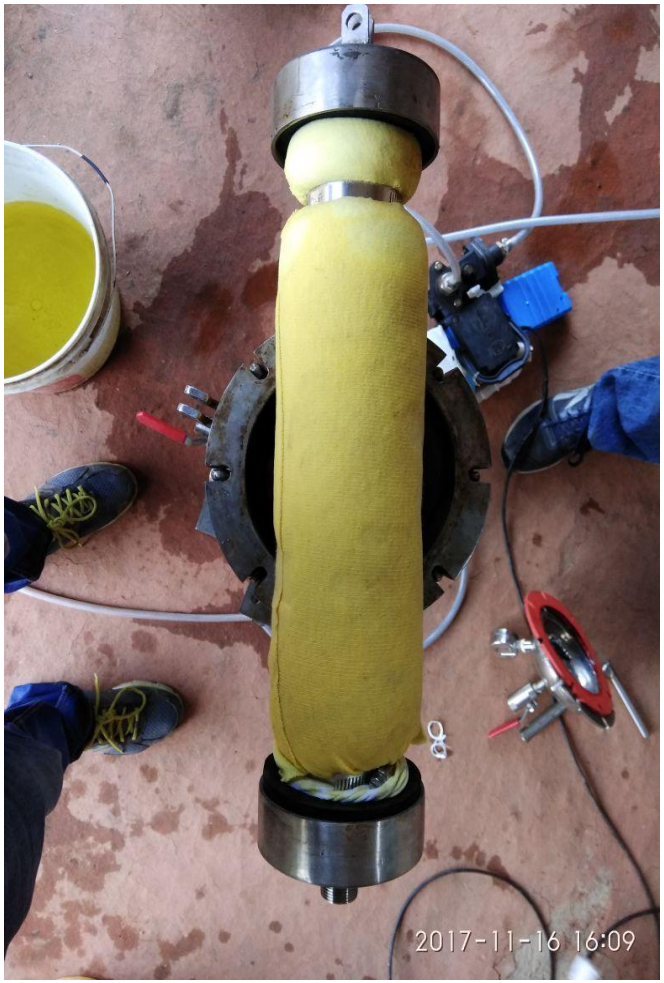
CARTRIDGES OF GRAFTED COTTON

Textile Dye Effluent Treatment

- 20,000 litres of effluent containing 200 mg/litre dyes can be treated using one kg adsorbent in ten cycles. The machine has 4 cartridegs of 3.5 kg each.
- Useful for small scale industries (20000-25000 litre/day effluent)
- Machine cost approx. USD 3000


800
600
400
200
800
600
400
200

Column after filteration



Contaminated water before and after treatment

Issues with the technology

- Multi step process
- Non Availability of radiation sources
- Choking of Cartridges
- Reusability and Disposal

Remediation of Issues

1. Redesigning of cartridges
2. Use of Disc filters
3. Reuse of bleached cartridges cotton for making bags
4. Coagulation and flocculation of waste water before use.

Team work


Thank you