بسم الله الرحمن الرحيم

Treatment of Contaminated Water Using Innovative Radiation Technology

By

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Royal Commission for Jubail & Yanbu

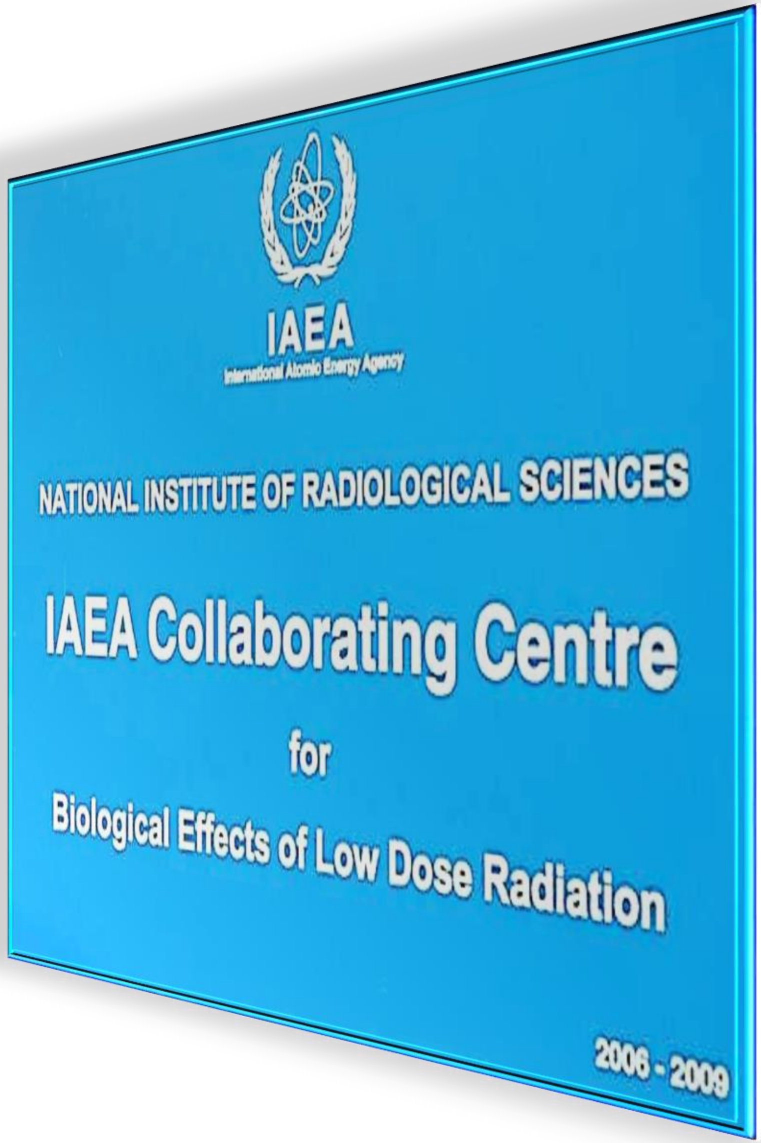
Discussion Topics

- *Introduction*
  - *IAEA Collaborated Research Project*
- *Aim & Methodology*
- *Results*
- *Conclusions*
- *References*

IAEA Coordinated Research Project

Introduction

- *The International Atomic Energy Agency (IAEA) promotes and supports research on radiation treatment of liquid effluents.*
- *During 2006 various collaborative research projects started with member states.*



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Introduction

Considerations:

•Pharmaceuticals wastewater treatment.

•Emerging chemicals of concern.

•Biosolids/sludge treatment.

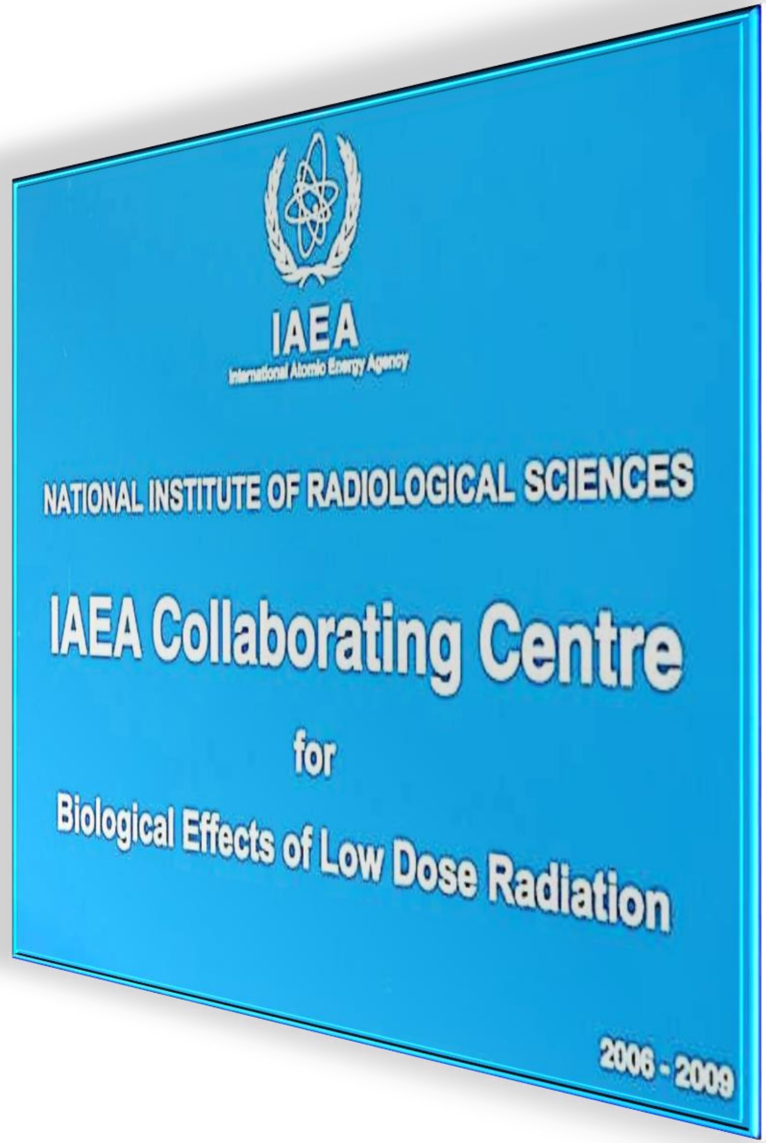
•RO Retentive Treatment.

•Agricultural Production – food and water.

•Economic models development.

•Salinity and agricultural practices.

•Innovative water treatment processes



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Introduction

- *A Collaborative Research Project (CRP) on Remediation of Polluted Waters and Wastewater by Radiation started early 2006 at Karachi Institute of Power Engineering (KINPOE).*
- *Various targeted pollutants studied in different phases.*
- *(IAEA-TECHDOC-1407)*

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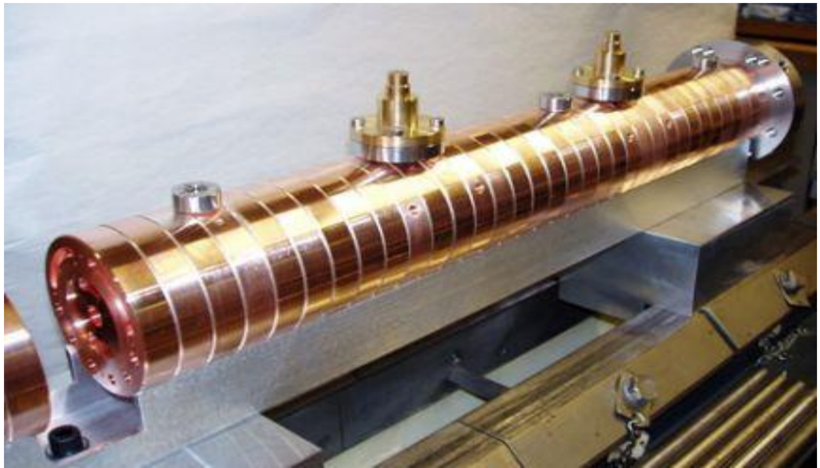
Rational of Using E-Beam

- *The most efficient process for generating hydroxyl radicals and defining reactive species for Advanced Oxidation Processes (AOPs)*
- *No need of additives – only the electrons*
- *No residuals – e.g. sludge's etc.*
- *Reduce sludge handling cost*
- *Interference with the solids is low*



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Rational of Using E-Beam

- *Aqueous radiation chemistry is well defined.*

$$H_2O \text{ WWW} \rightarrow 2.7 \bullet OH + 0.6 \bullet H + 2.6\, e^- + 0.45\, H_2 + 0.7\, H_2O_2 + 2.6\, H^+$$

- *Equipment is reliable – with Insulated Core Transformers (ICTs) having 98 – 99 % uptime*
- *Mobile trailer may be utilize (built in 1963).*
- *Economical than most of the treatment methods.*

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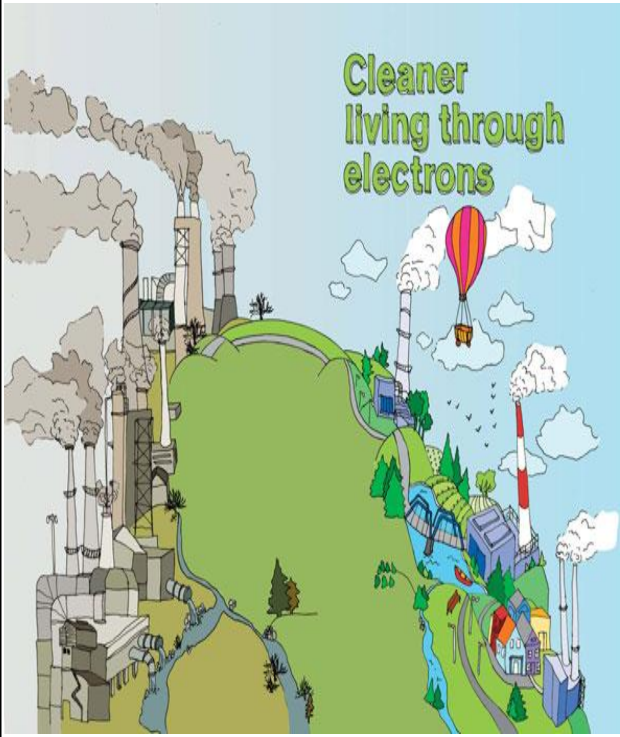
Comparison of E-Beam Technology with Other Methods

	Chlorination	UV Radiation	Ozone	Electron Beam
Advantages	Enhances colour removal Least expensive disinfection	Effective against bacteria & viruses at low dosages	More effective than chlorine for inactivation of viruses.	Very effective against bacteria & viruses at low dose. Colour and taste removal Simple design feasible to large scale.
Disadvantages	Forms THMs Chlorine gas is a hazardous corrosive gas.	Not efficient in large Scale Water with high calcium, turbidity & phenols may not be applicable High Maintenance cost of UV lamp.	Not efficient in large scale By-products are formed (bromide, aldehydes, ketones). High Initial cost of equipment	High capital costs



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Aim & Methadology of the project

Aim:

- *An E-Beam technology utilized to decontaminate wastewater having targeted pollutants (COD, BOD & MTBE, Current study).*
- *Program was aimed to establish optimal treatment methodologies*

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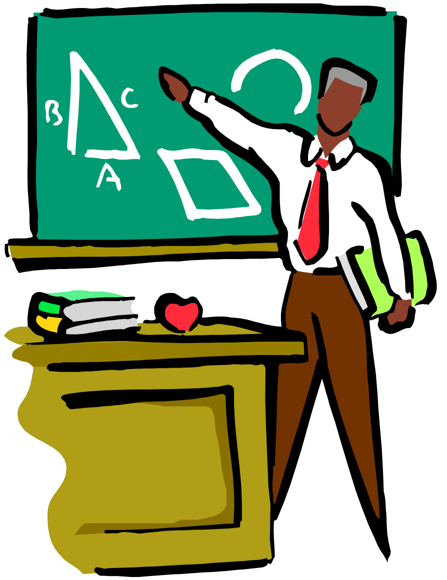
Methadology:

- A 50 KeV E-Beam (WASIK-A, Japan).
- About 850 gallon of wastewater brought from Karachi Industrial area in sealed containers.
- E-Beam doses 1.22 kGy to 8.97 kGy.
- Treatment time 15 sec/gallon.
- 42 experimental runs were performed with wastewater. (US-EPA-524.2, 1992, GC/MS)



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Objectives

- *Efficiency of E-Beam to remove targeted pollutants including MTBE.*
- *System/Process Reliability.*
- *Check Reuse Option.*
- *Cost estimation.*
- *Safety Consideration.*

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➤ *Charecteristics of Wastewater*

Serial No:	Parameters	Units	Value Range
1	pH	-	6.49 ± 0.3
2	TSS	(mg/l)	400 ± 4
3	TDS	(mg/l)	236 ± 2
4	TS	(mg/l)	636 ± 6
5	**COD**	**(mg/l)**	**278 ± 2**
6	**BOD_5**	**(mg/l)**	**75± 2**
7	Alkalinity	(mg/l)	184 ± 2
8	Amonia-N	(mg/l)	10.6 ±0.5
9	NO_3-N	(mg/l)	3.2 ± 0.3
10	Total phosphate	(mg/l)	28.3 ±1.1
11	Total Coliform	MPN (#/100 ml)	420 ± 4
12	**MTBE**	**(mic-g/l)**	**310± 5**
13	EC	(ds/m)	0.6 ± 0.07

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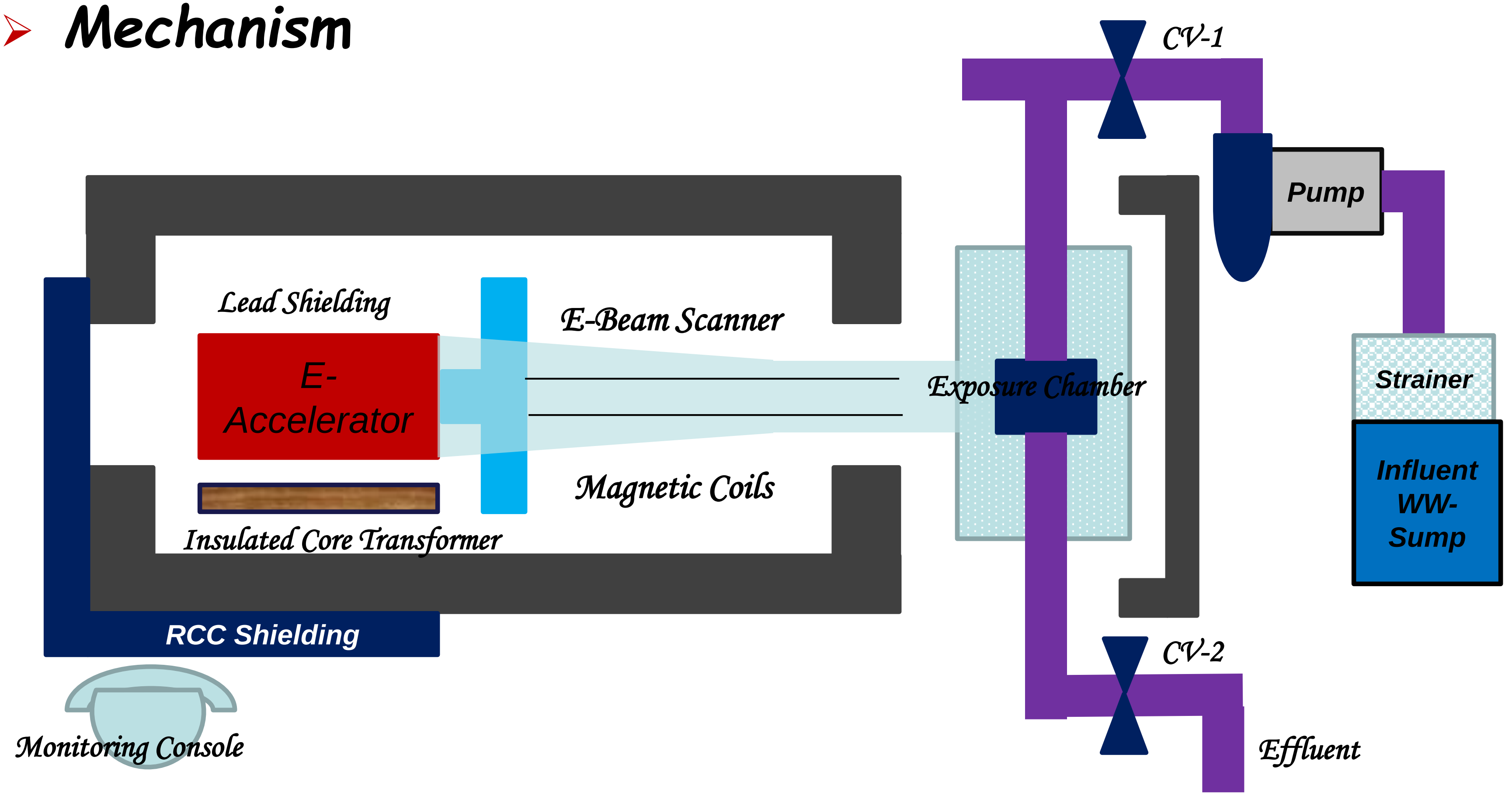
- **Mechanism**



Safety Consideration:

up to 0.02 mSv near nuclear installation sites

world-wide average to all workers is 0.7 mSv.

Radiation level all the time was below background level (0.014-0.017 mSv)

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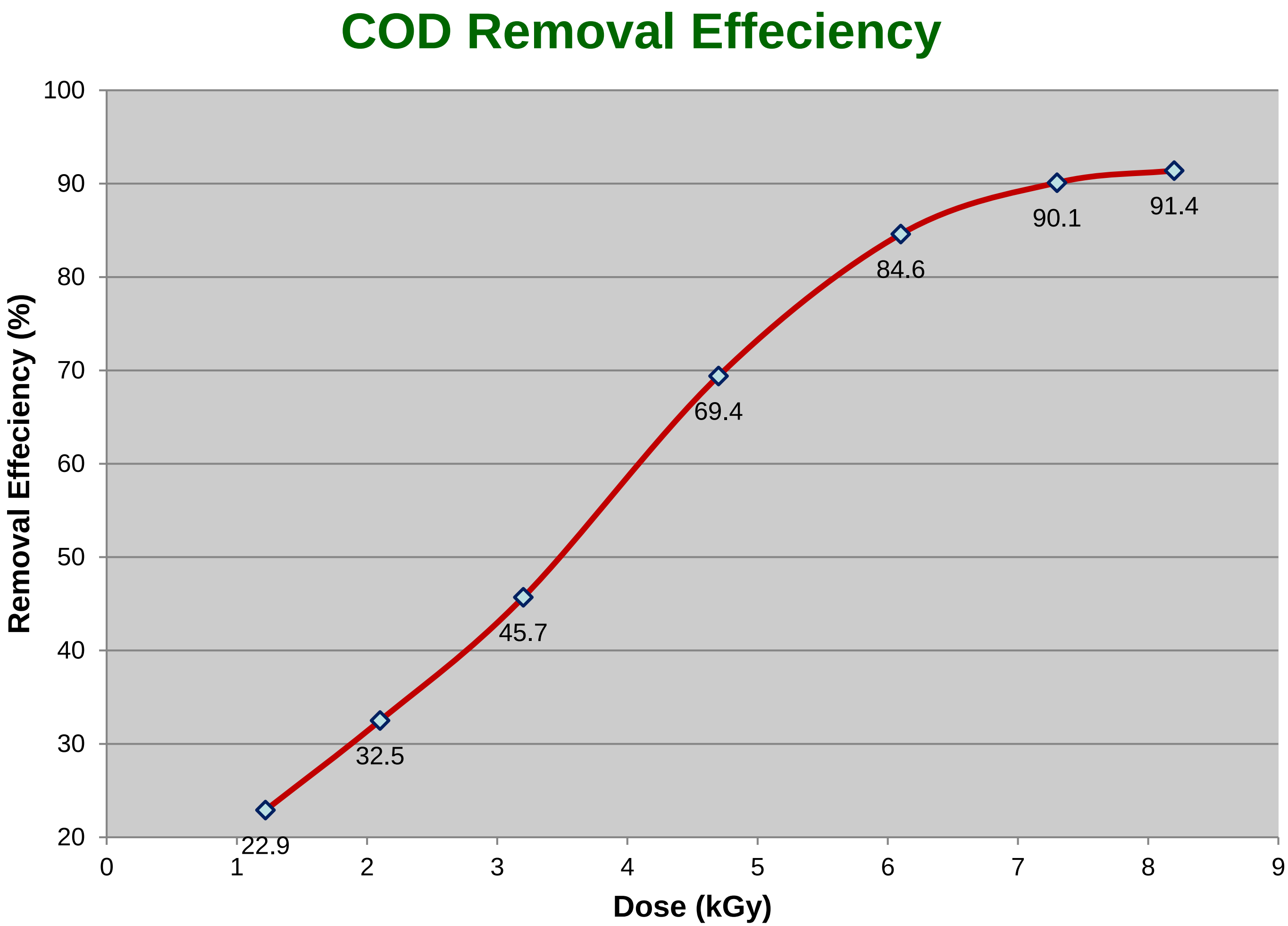
- **Results**



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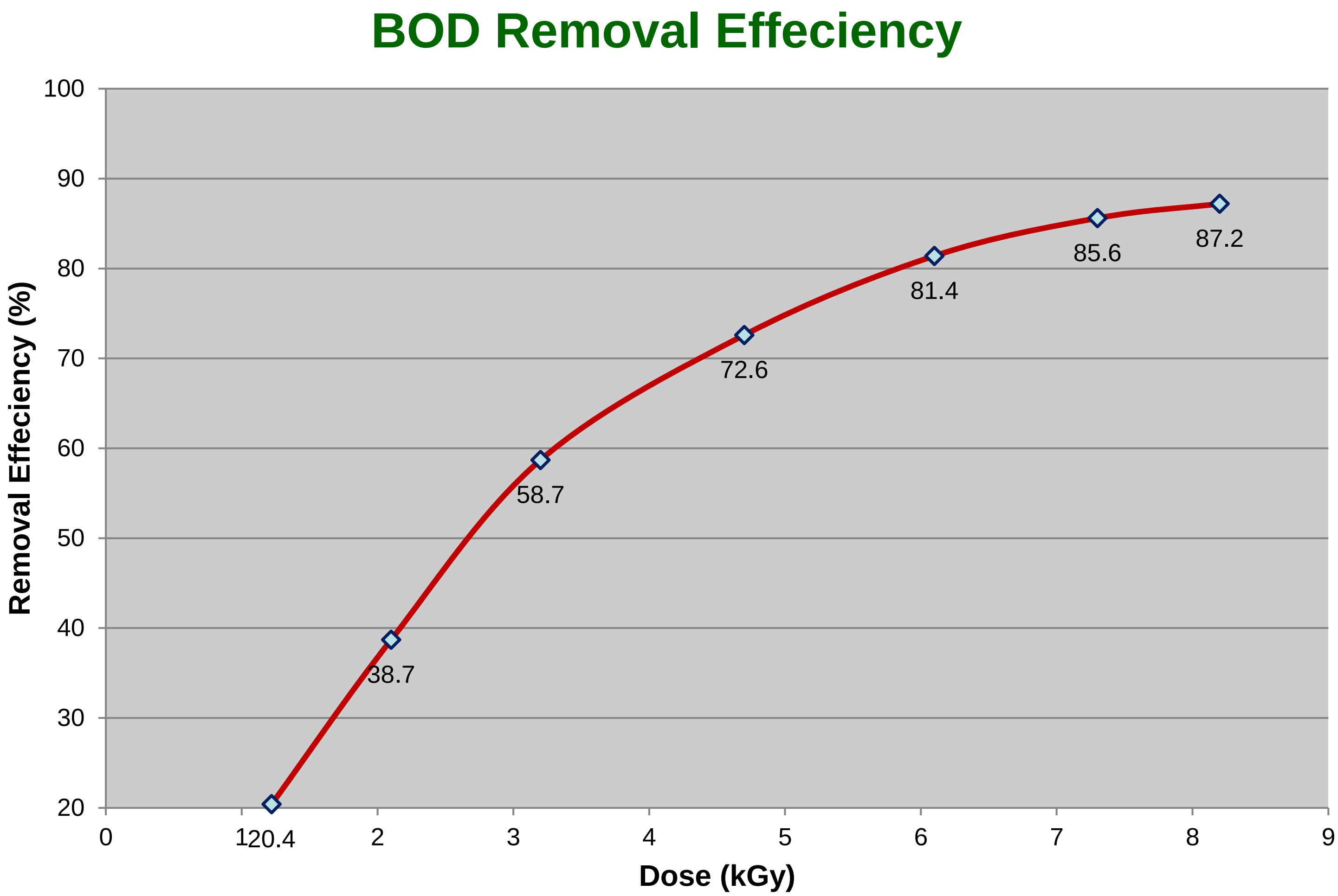
➢ **Results**



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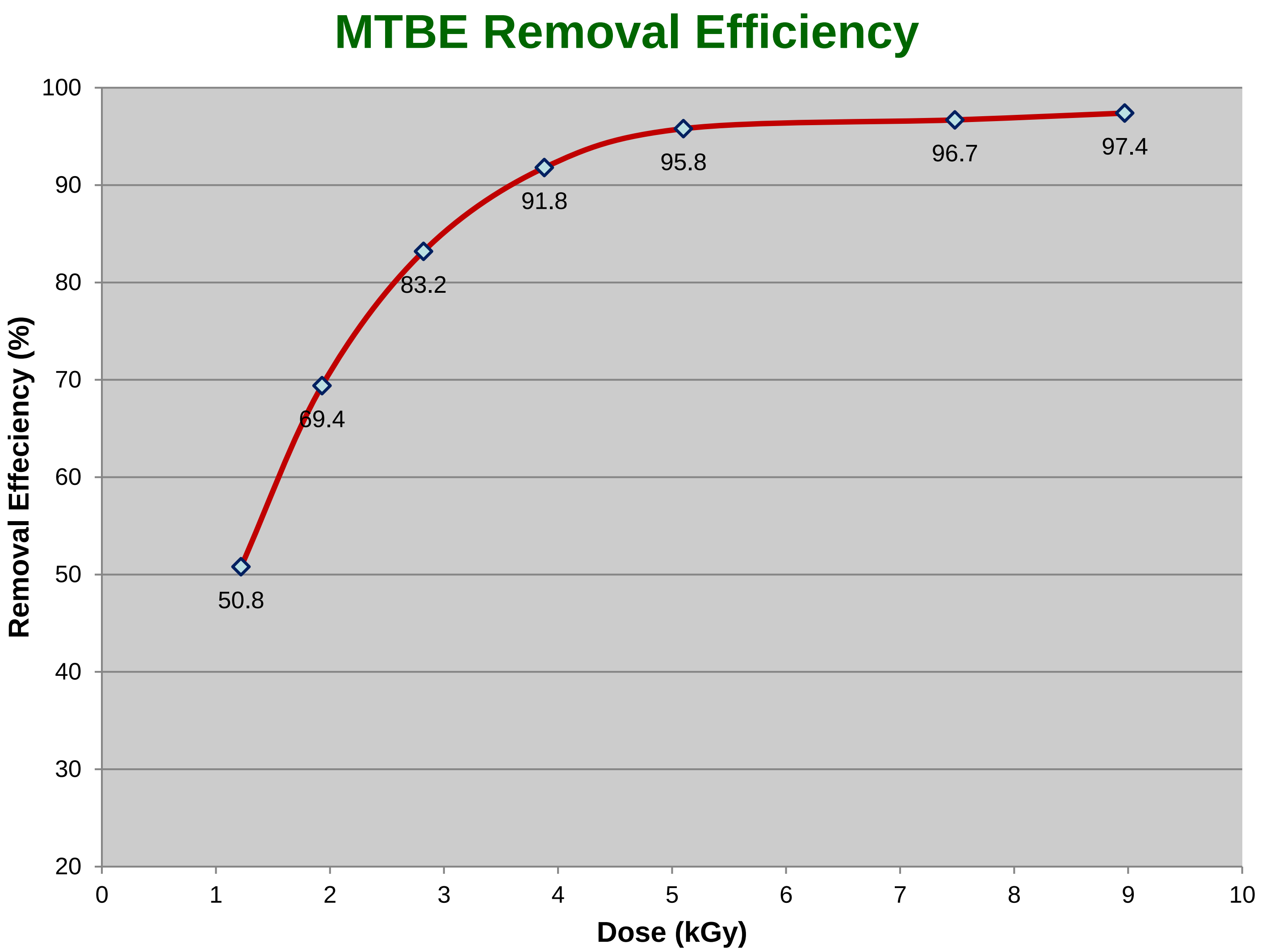
- **Results**



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Charecteristics of Wastewater After Irradiation & Comparison with Various Reuse Standards (Reuse Consideration)

Serial No:	Parameters	Units	Initial Value Range	Final Value	California (2009)	USEPA (2004)	PME (2001)
1	TSS	(mg/l)	400 ± 4	385 ± 2	-	5	15
2	COD	(mg/l)	278 ± 2	23.7 ± 1	25	30	150
3	BOD_5	(mg/l)	75 ± 2	9.4 ± 2	20	10	25
4	Amonia-N	(mg/l)	10.6 ±0.5	4.8 ±0.3	-	-	1
5	Total phosphate	(mg/l)	28.3 ±1.1	2.2 ±0.4	-	0.15	1
6	Total Coliform	MPN (#/100 ml)	420 ± 4	0	2.2	0	1000
7	MTBE	(mic-g/l)	310± 5	6.2± 2	13	20	-

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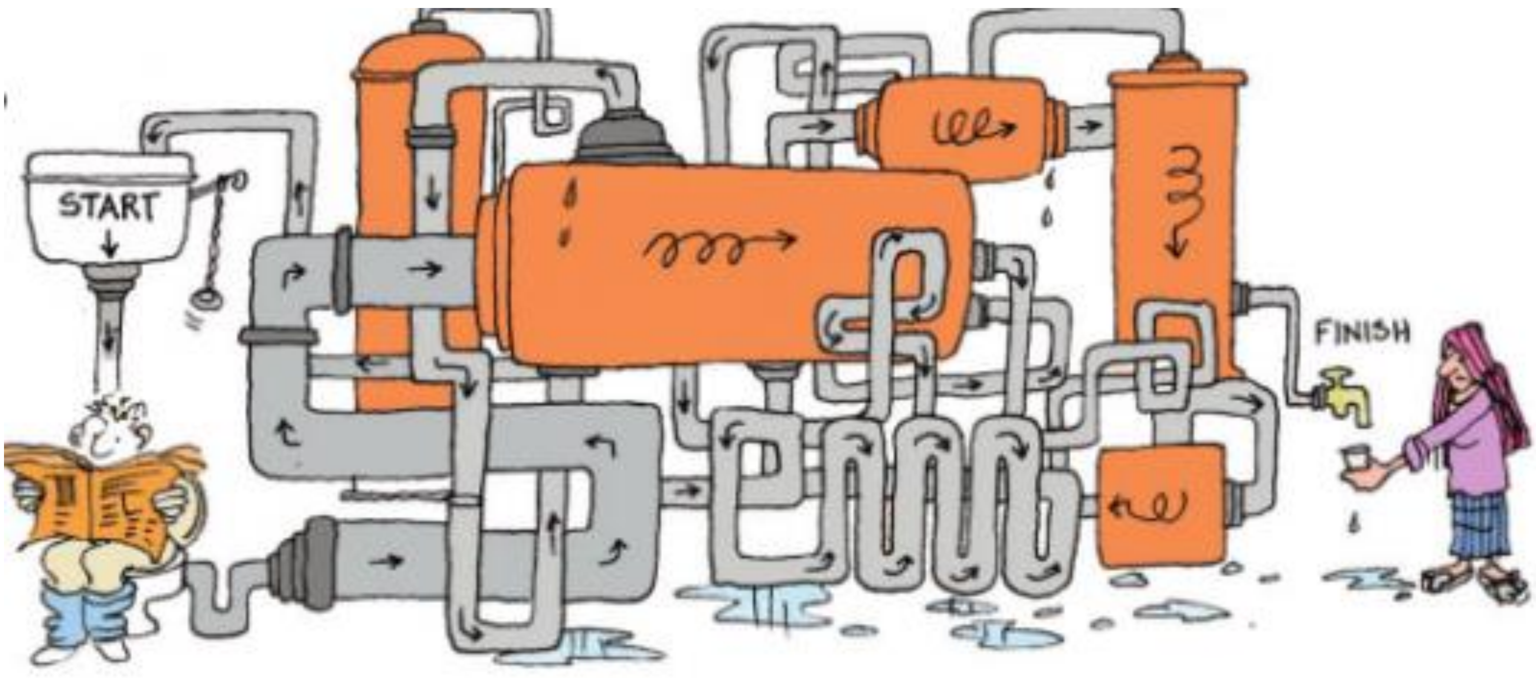
- ***Complete treatment of wastewater required for reuse purpose***

- ***A series of unit operations & unit processes are required.***



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Wastewater should be treated in a series of units to achive the reuse target

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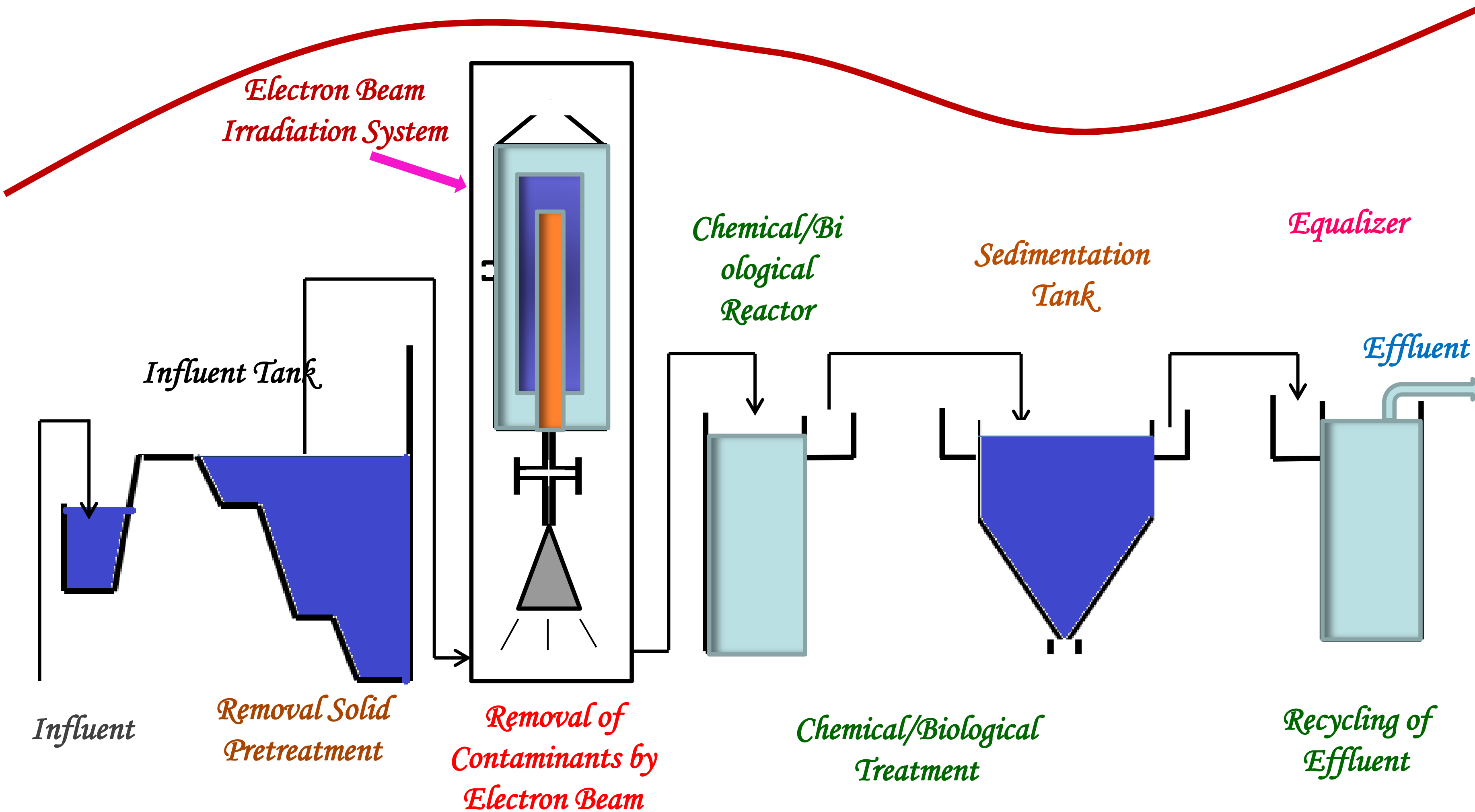
- **Suggested process flow diagram for complete treatment of wastewater to be reused**



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Cost analysis for E-Beam treatment of wastewater

MGD	No. of Beams*	Installed Cost	Annual Cost†	Annual Maintenance Cost‡	Annual Electrical Costs§	Annual Labor Cost**
0.5	1	$2,000,000	$140,000	$100,000	$70,000	$50,000
1	2	$3,500,000	$245,000	$175,000	$140,200	$50,000
3	4	$6,000,000	$420,000	$300,000	$280,300	$50,000
10	12	$18,000,000	$1,260,000	$900,000	$841,000	$100,000

MGD	No.of Beams*	Total Annual Costs††	1000 Gallons Per Year Treated	$/1000 Gallons
0.5	1	$360,000	182,500	$1.97
1	2	$610,200	365,000	$1.67
3	4	$1,100,300	1,095,000	$1.00
10	12	$3,101,000	3,650,000	$0.85

* 100 kW E-beam units at a cost of $1,000,000 per unit.
† Based on 20-year amortization at 7% interest rate.
‡ Calculated at 5% of installed cost.
§ Number of beams × 100 kW × $0.08/kWh × 8760 hr/yr.
** One/two full-time operators at $25/hour.
†† Annual Cost + Maintenance + Electrical + Operators.

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Conclusions

- *Efficiency of E-Beam to remove **COD**, **BOD** & **MTBE** was found to be more than **70%**, **75%** and **95 %** respectively (dose of 5kGy) .*
- *System availability was up to 99%.*
- *Treated wastewater quality compared with various standards for reuse and a treatment scheme is suggested.*
- *Continuous monitoring of radiation levels shows that the radiation is within permeable limits and process is safe.*
- *Cost analysis shows that for 10MGD cost is $0.85/1000 G.*


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Thank You

"There must be a reason why some people can afford to live well. They must have worked for it. I only feel angry when I see waste. When I see people throwing away things we could use."

Mother Teresa