Disinfection of Total Coli-forms in the Effluent from Municipal Wastewater Plant with e- Beam

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EB TECH Co.

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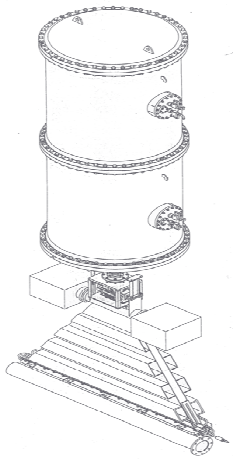
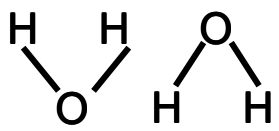
- Introduction
- Experimental
- Results and discussion
- Summary





Water Molecule

e_{aq}

OH*

H*

H_2O_2

Active Radicals

Harmful Organic in Waste water

- Complete Decomposition → H_2O, CO_2
- Partial Decomposition
- Suspended solid
- Monomer to Polymerization

→ Coagulation

- Removal of Toxic group → Bio-Treat
- Removal of Color, Odor

Principles of Wastewater treatment with electron beam

Application of e-beam on water/wastewater treatment

-. Wastewater from Textile Dyeing Companies

-. Wastewater from Papermill

-. Leachate from Sanitary Landfill

-. Wastewater containing Heavy metals (Cd,Hg,Pb,Cr^{+6})

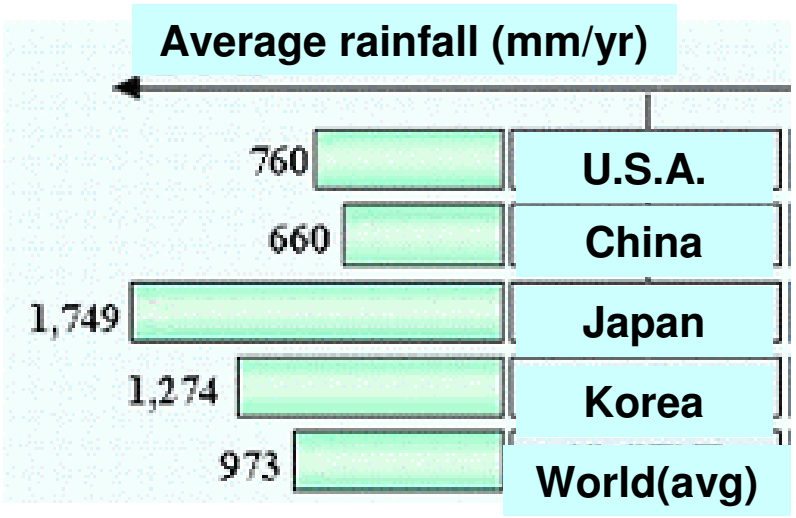
-. Re-use of effluent from Municipal wastewater plant

-. Remediation of contaminated water (PCB,Explosives)

-. Contaminated Underground water

-. Drinking water

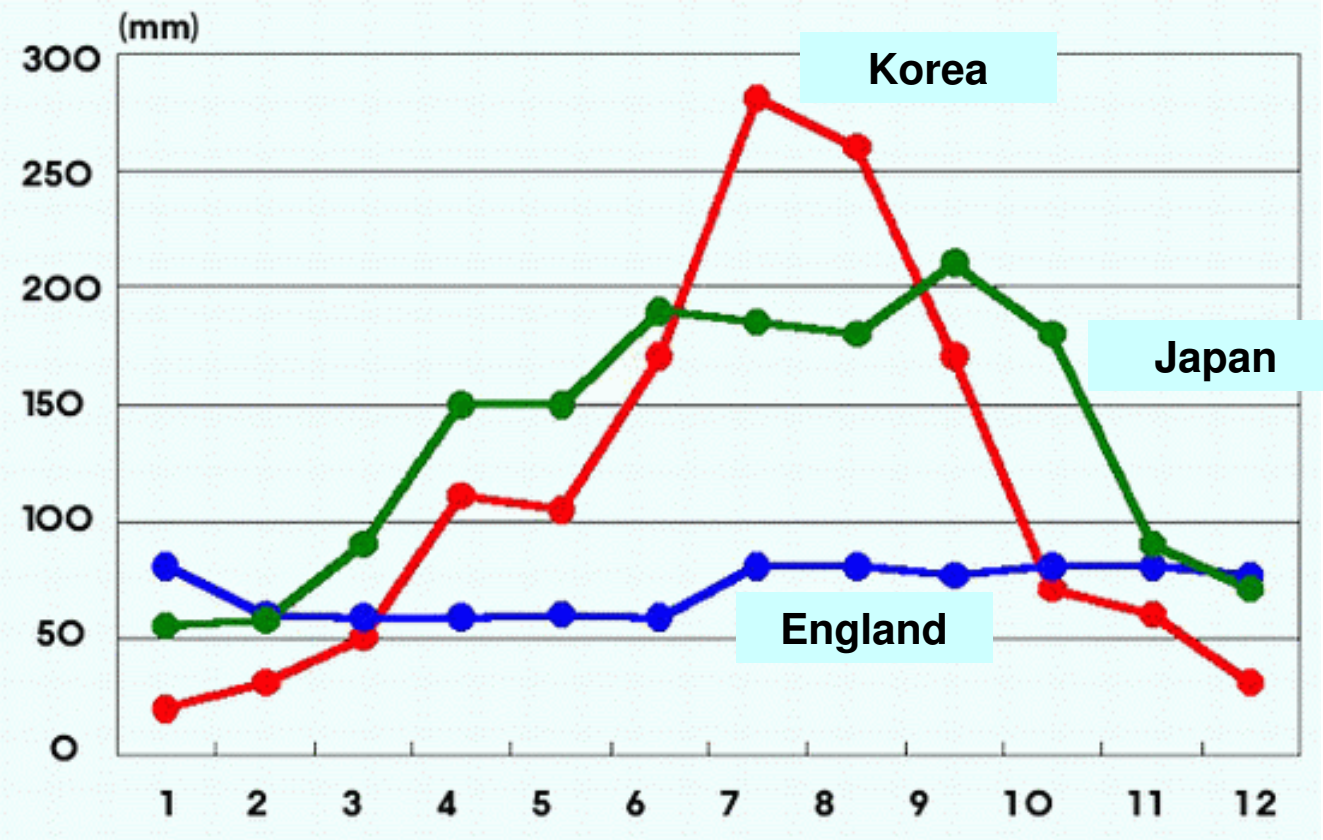
Annual Rainfall of Korea and other countries



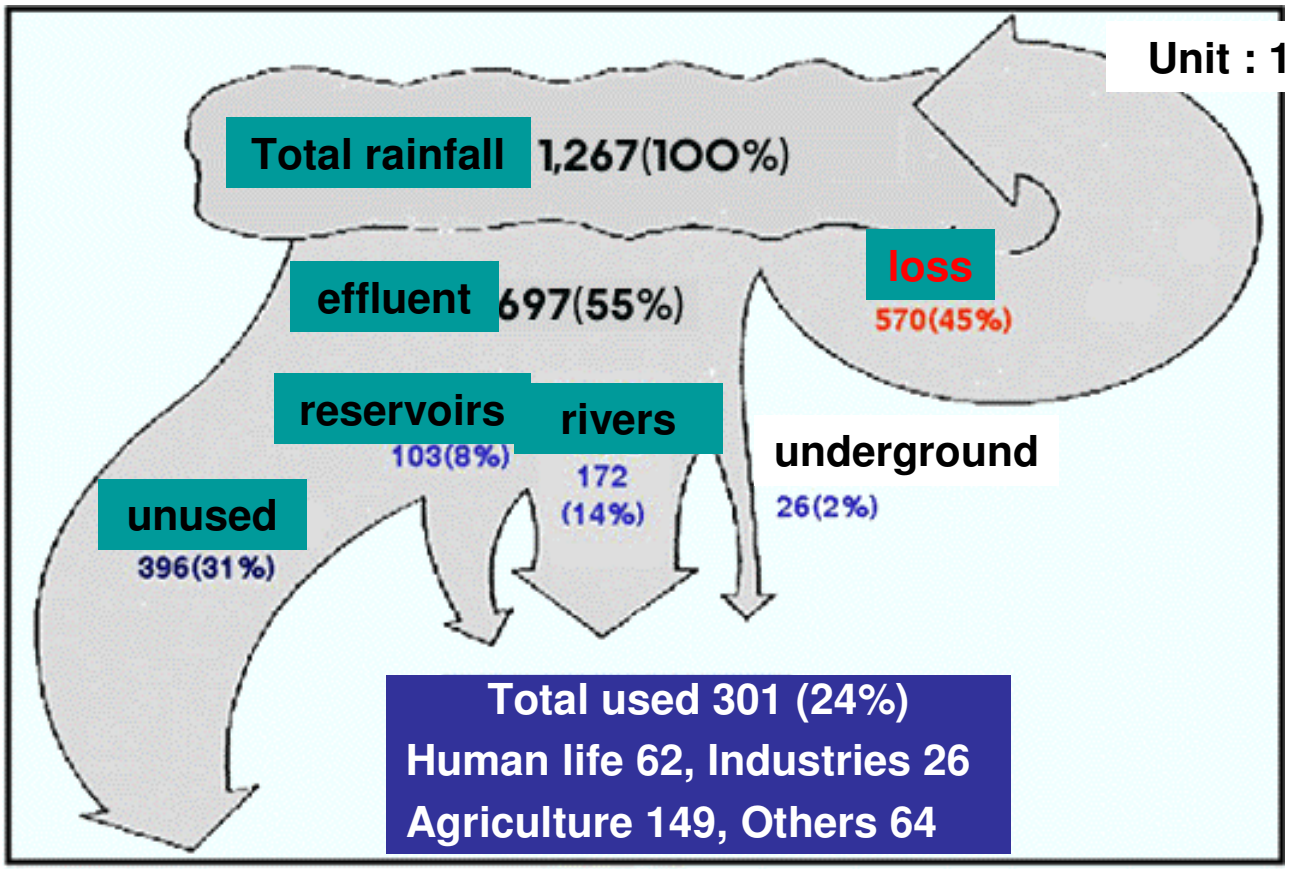
Average Annual Rainfall : 1.3 greater than World average

Population density : 3rd in the World

Annual Rainfall per capita : 1/11 of World Average



Monthly Rainfalls in Korea and other countries



Usage of Annual Rainfalls (Data from Ministry of Environment)

Supply and demand of fresh water in Korea

($10^8 m^3$/year)

	1994	2001	2006	2011
Demand	29,901	33,640	34,991	36,652
Supply	32,219	34,290	34,541	34,655
Shortage	-	-	450	1,997

Average annual rainfall in Korea is 1.3 times greater than that of World, but it varies too much with season and area to control for withdrawal. Only 24% of rainfall could be accessible for human uses.

The goal of irradiation on municipal wastewater

-. Removal of COD, BOD ?

-. Decrease of T-N, T-P ?

-. Removal of Color, Odor ?

-. Decrease the number of microorganism and re-use

Why Electron Beam Processing?

- Control the number of coli-forms in the effluent
- Remove odor, color and reduce other residues for re-use in irrigation or industrial purposes
- Bio-system is no good to control the number of e-coli
- Ozone, UV and others are not good for large quantity

Comparison of Disinfection systems

Chlorination	UV radiation	Ozone	Electron beam
Enhances color removal. Effective biocide Least expensive disinfection.	Effective against bacteria & viruses at low dosages.	More effective than chlorine for inactivation of viruses. Biocidal activity is not influenced by pH.	Very effective against bacteria & viruses at low dose. Enhances color, taste & odor. Simple design and feasible to large scale.
Forms THMs. Chlorine gas is a hazardous corrosive gas.	Water with high calcium, turbidity & phenols may not be applicable to UV disinfection. Maintenance cost of UV lamp is high.	byproducts are formed (bromide, aldehydes, ketones). Initial cost of ozonation equipment is high.	Needs Shielding (X-ray)

Status of Municipal Wastewater Treatment in Korea

- Municipal Wastewater plant : 279
- Total amount of water treated : 18,399,000 ton/day
- Capacity : 80% of total municipal wastes
  95% for 195 main stream area

- Mainly activated Sludge Process
- Good to remove Suspended Solids and Organic matters
- However, not sufficient for remove T-N, T-P and microorganisms

→ New Technology Required

Control of Wastewater in Daejeon City

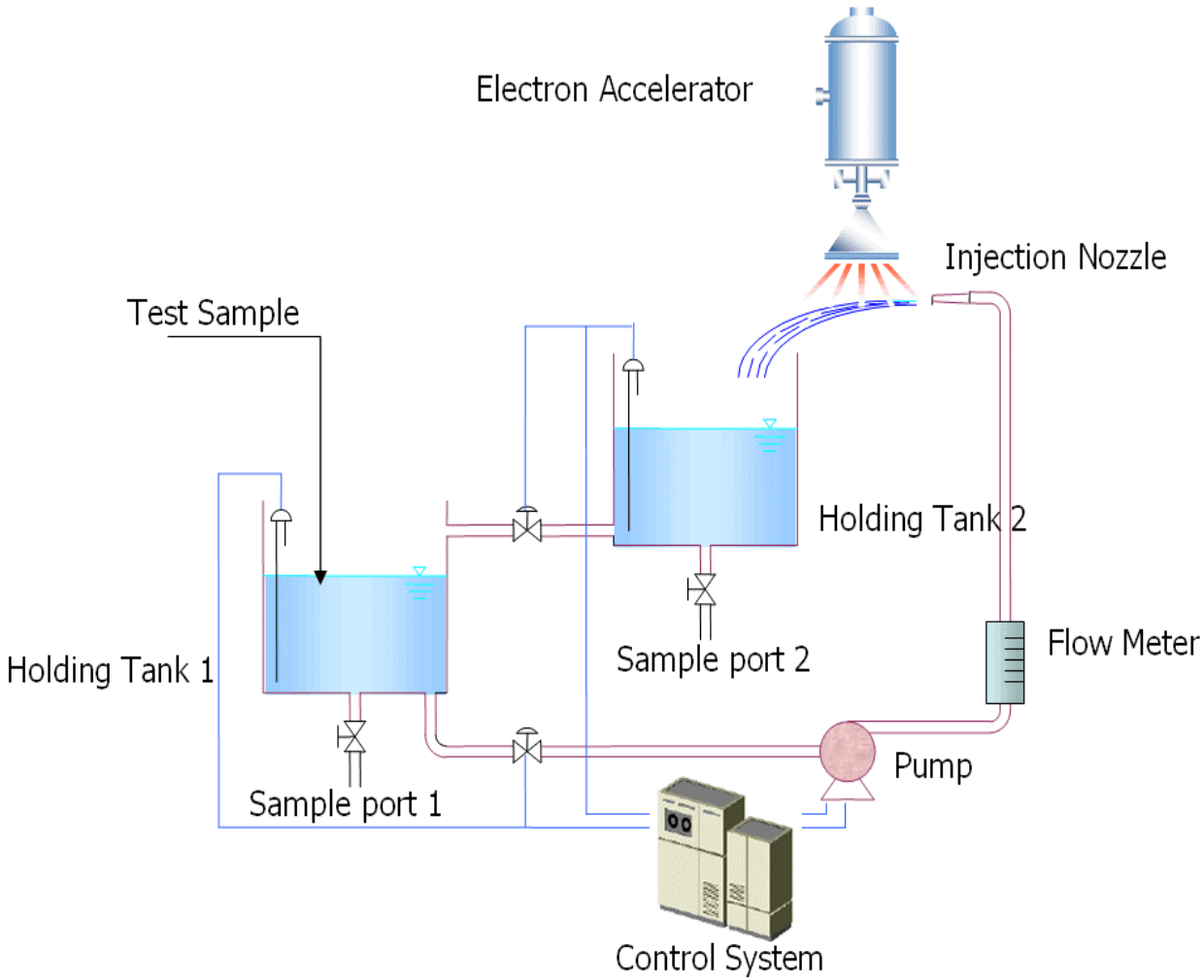
	BOD (mg/l)	COD (mg/l)	SS (mg/l)	T-N (mg/l)	T-P (mg/l)	E-coli [(a)] (CFU/ml)
Influent (average)	115.1	127.4	201.8	34.2	4.5	N/A
Regulation for effluent	<20	<40	<20	<60	<8	<3000
Under Control	<14	<14	<15	<25	<1.5	
As of July 10, 2002	8.9	11.2	7.2	16.2	4.3	28,000

(a : Effective from 2003)

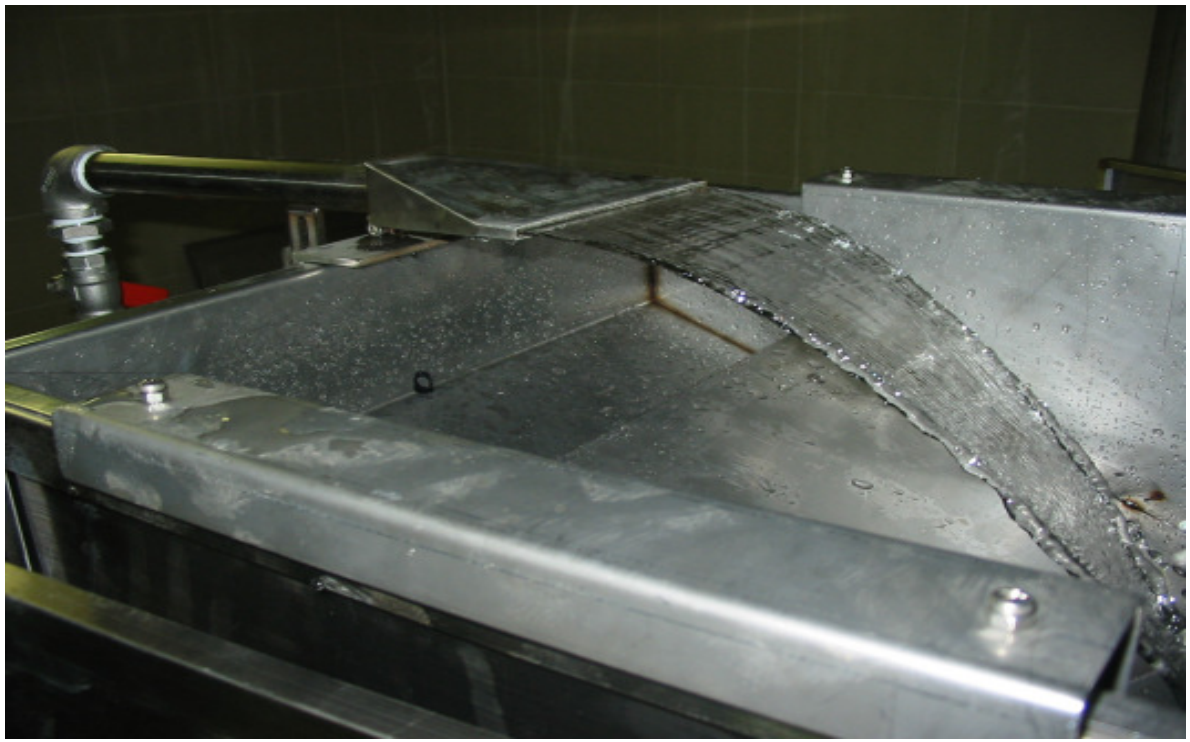
Experimental Methods

Items		Condition
Electron Accelerator	Beam power (MeV)	1
Reactor [Nozzle type]	Flow (ton/day)	50
	Dose (kGy)	0.2 – 1.0
	Velocity (m/sec)	3
Analysis items	e-coli	Membrane Filter
	Total coli-form	Membrane Filter
	BOD, COD, SS, TOC	Standard methods

Electron Beam Irradiation System



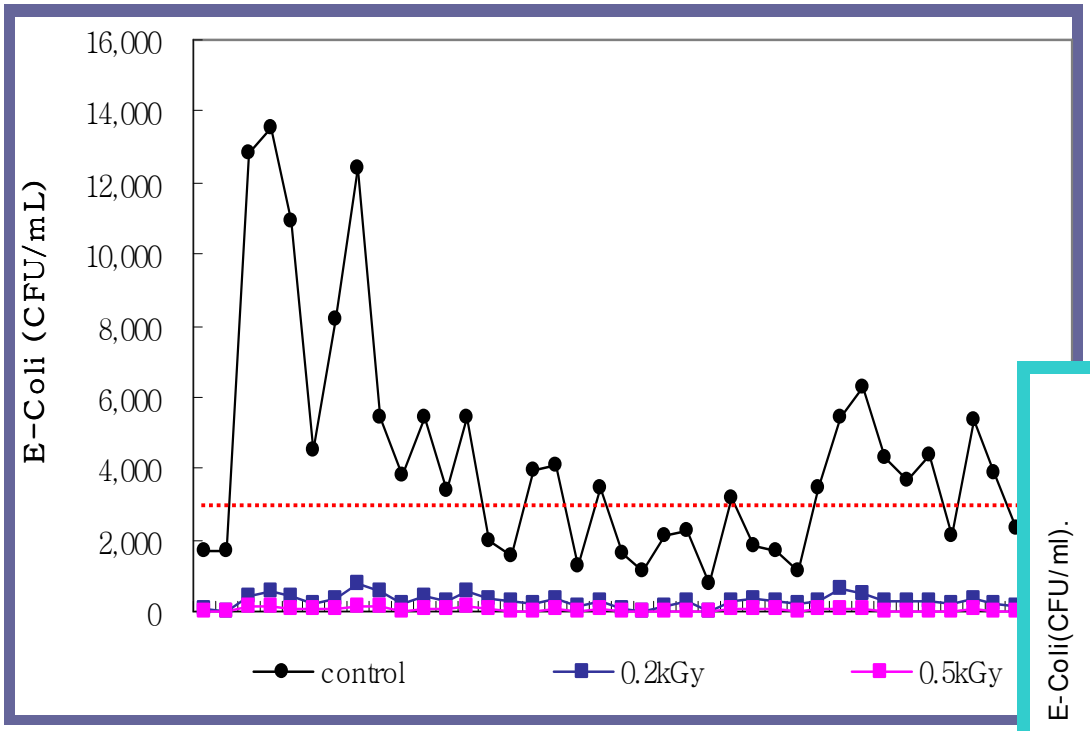
Nozzle type injector for Irradiation

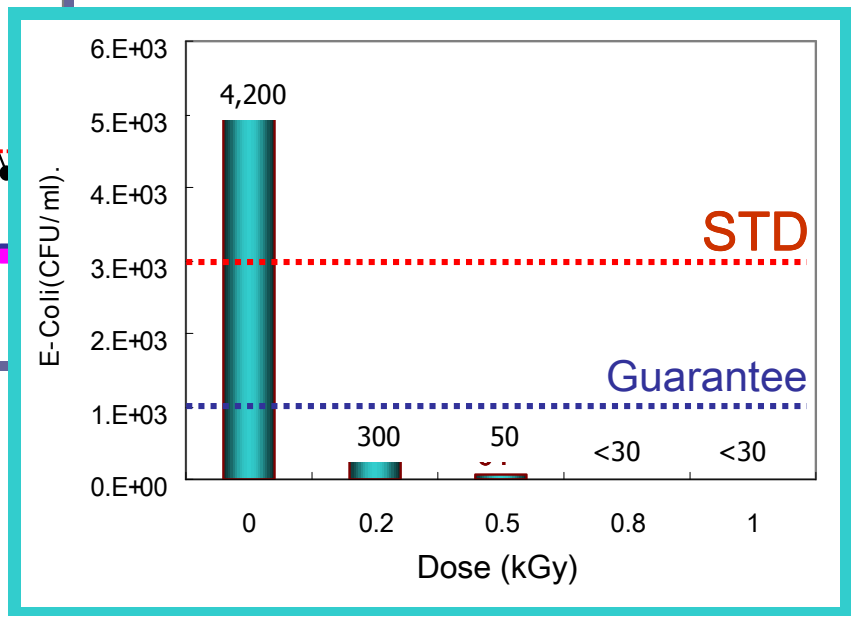


Decrease of Coli-form upon irradiation

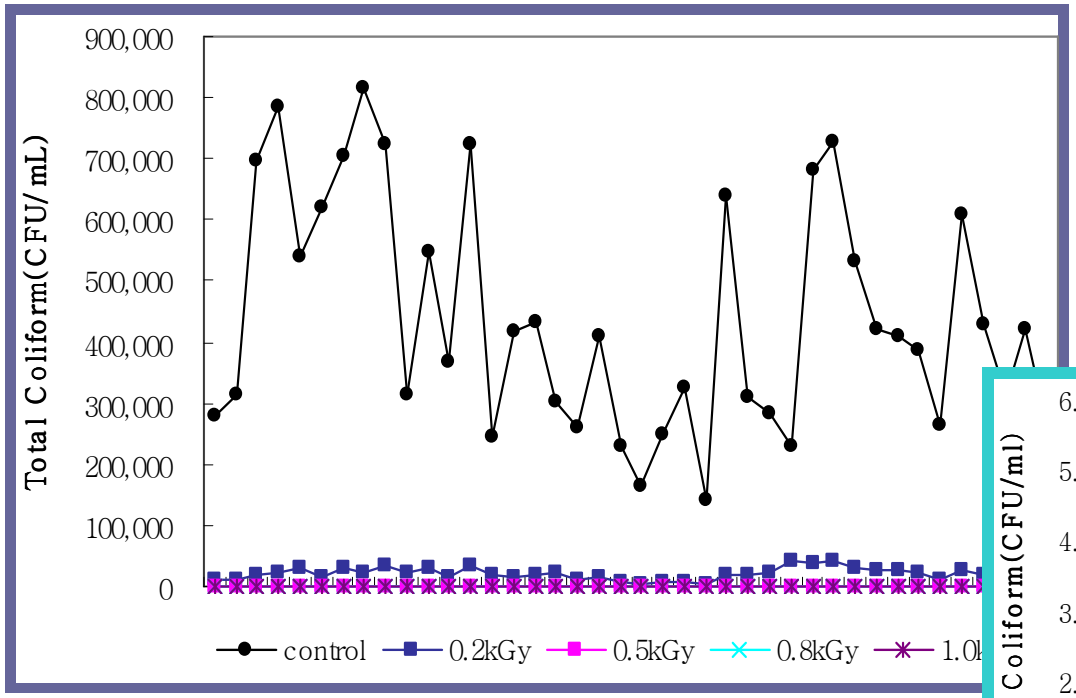
Q = 50ton/day		E-Coli (CFU/ml)			Total Coli-form (CFU/ml)		
		Max.	Min.	Ave.	Max.	Min.	Ave.
Un-chlorinated Secondary Effluent		14,000	800	4,200	820,000	140,000	440,000
Electron Beam	0.2kGy*	770	20	300	42,000	1,300	20,000
	0.5kGy	170	20	50	42,000	1,300	3,000
	0.8kGy	<30	<30	<30	1,800	160	400
	1.0kGy	<30	<30	<30	760	30	100

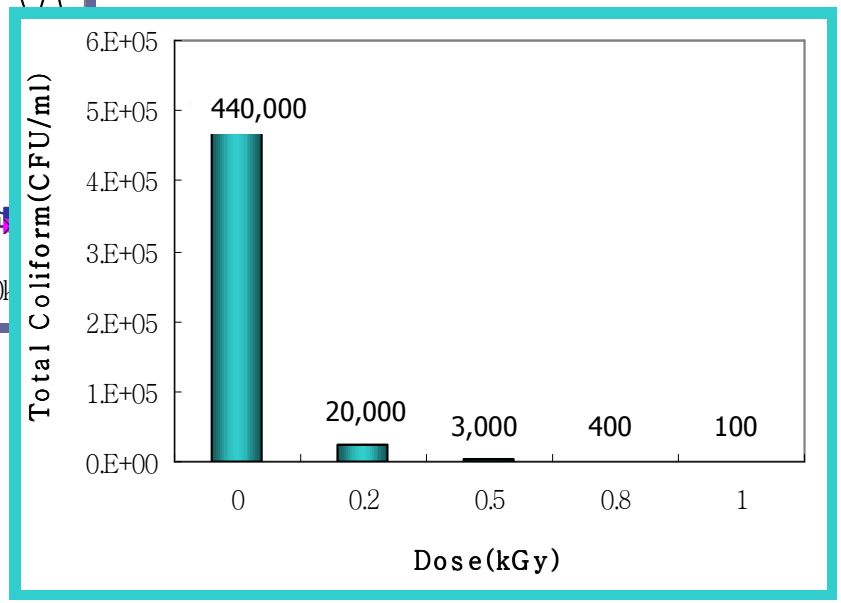
E-Coli

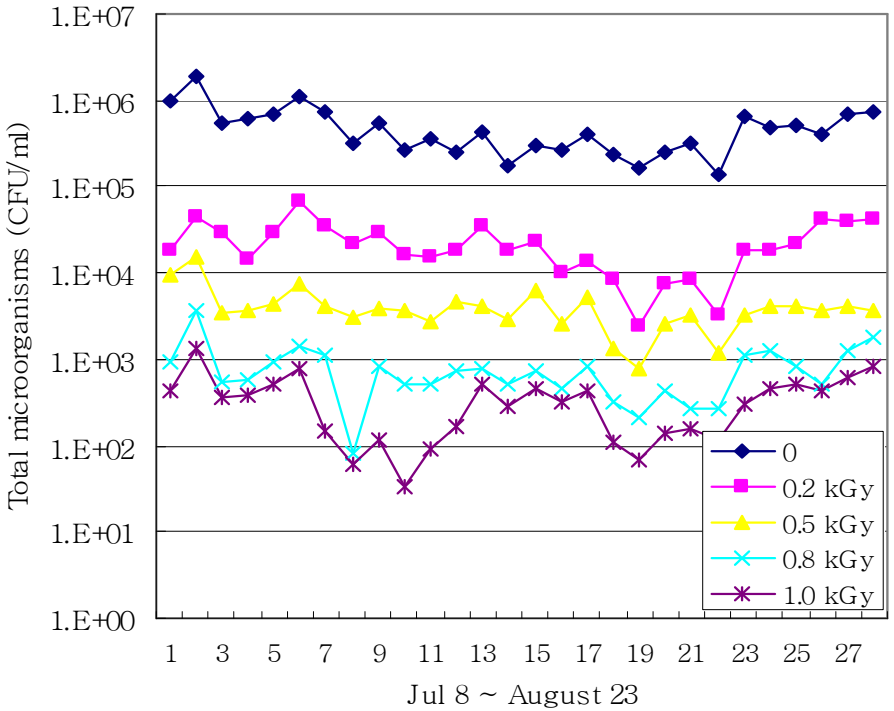

E-Coli (CFU/mL)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
control
0.2kGy
0.5kGy

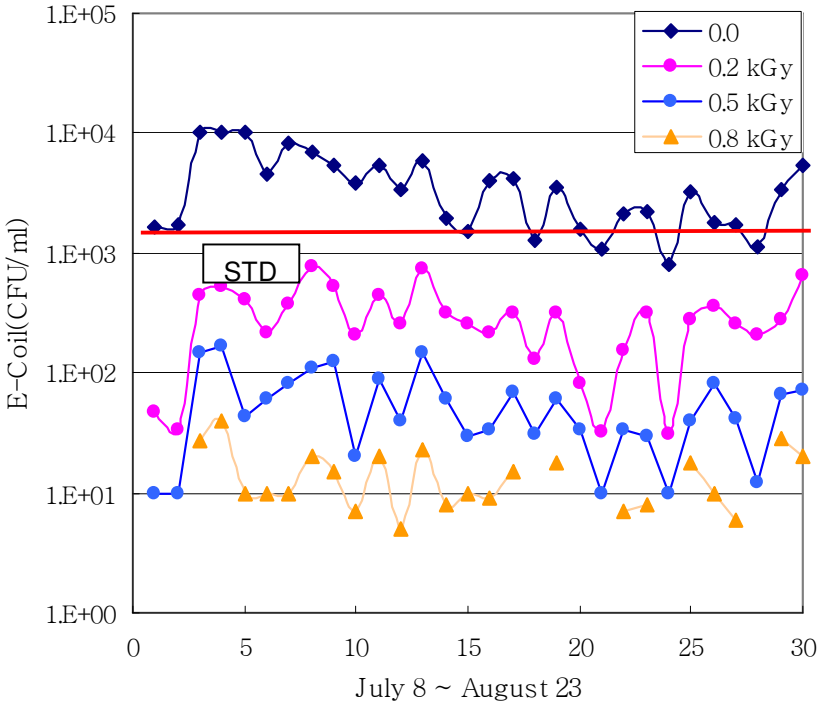

E-Coli(CFU/ml).
6.E+03
5.E+03
4.E+03
3.E+03
2.E+03
1.E+03
0.E+00
4,200
300
50
<30
<30
STD
Guarantee
0
0.2
0.5
0.8
1
Dose (kGy)

Total Coli-form

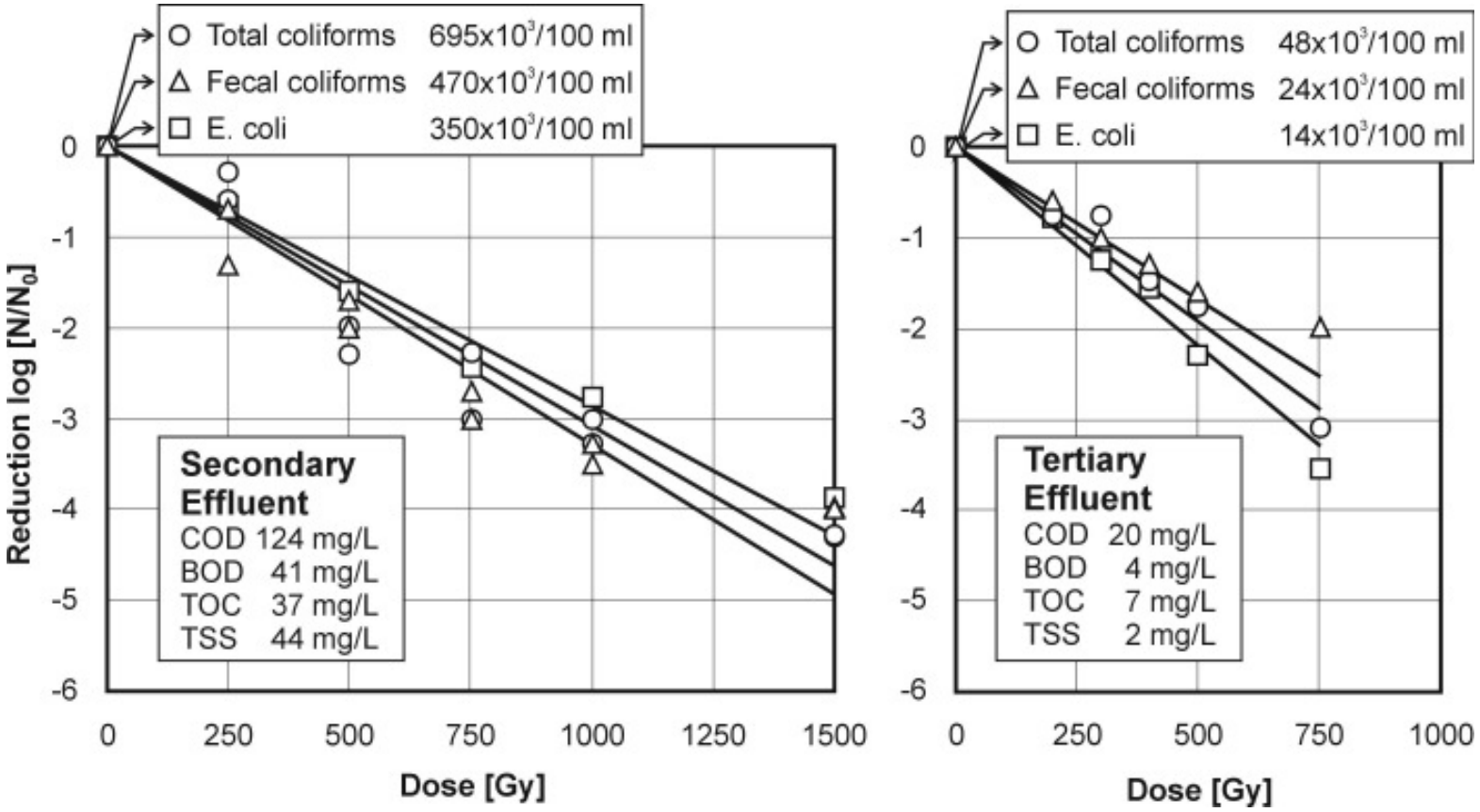








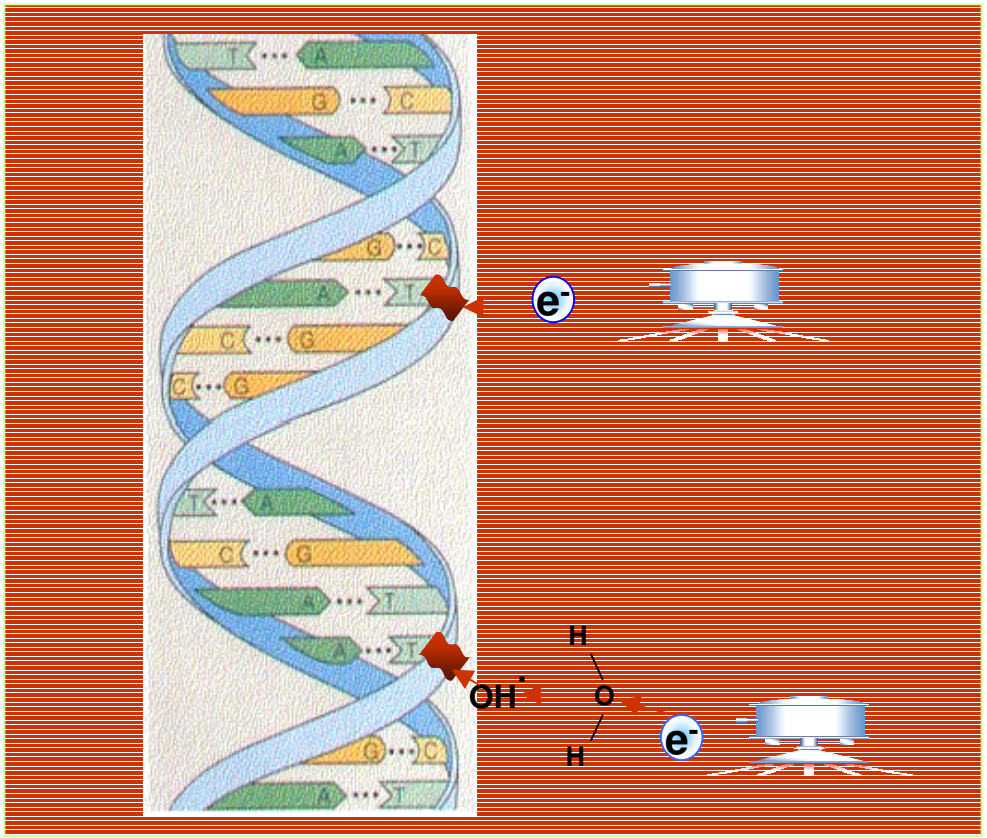
Variation of microorganisms in Sewage effluent



Radiation induced inactivation of some coliforms in different effluents by means of electron beam irradiation

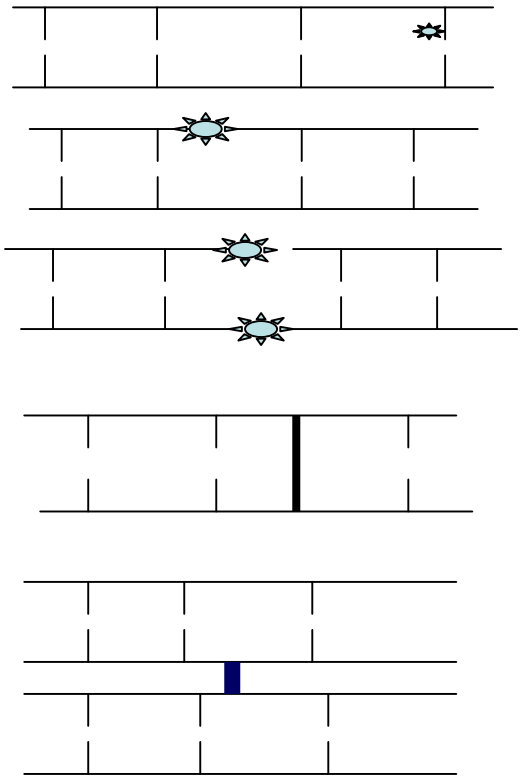
(P. Gehringer et al., "High energy electrons for reclamation of effluents from municipal wastewater treatment plants", IWA 5th Congress, Morocco 2004

Disinfection Mechanisms by E-Beam



- Direct action
- Indirect action
  : Radical reaction

Direct effect as well as indirect effect through water radiolysis products damage DNA and stop reproduction



Base Pair damage

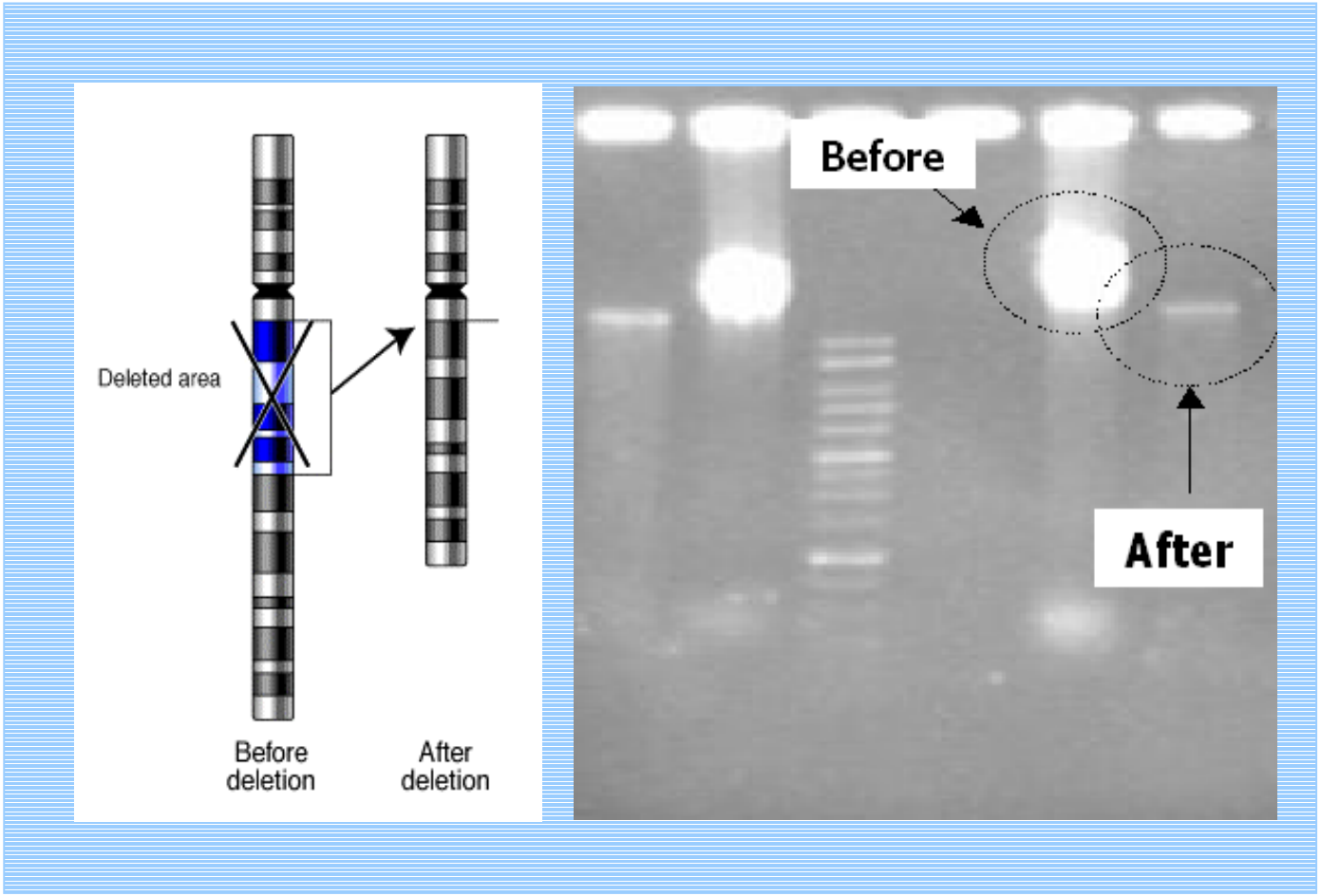
Single strand break

Double strand break

Intra molecular cross-linking

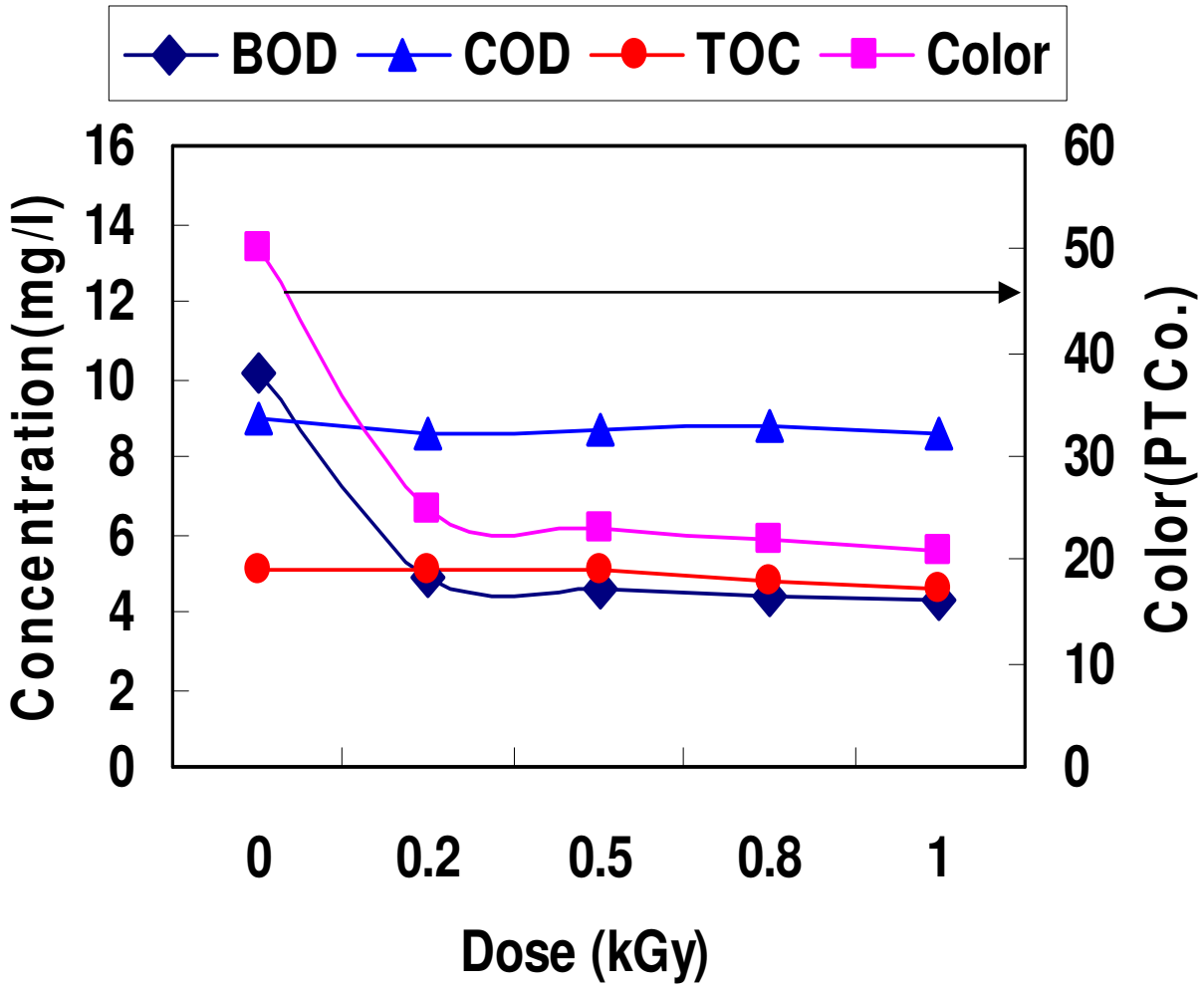
Intermolecular cross-linking

S. Sabharwal, et al., “Technical and Economic Aspects of Radiation Hygienization of Municipal Sewage Sludge Using Gamma Irradiator” IAEA CM, Bulgaria 2004



Variation of DNA at E. Coli before and after electron beam irradiation (Electrophoresis)

Variation of BOD, COD, TOC & Color



Design and Estimation of E-beam plant

-. For Treating Effluent from Municipal Wastewater Plant or from the Contaminated Ground water

-. To re-use in Irrigation or Industrial purposes

-. Design Basis

+. Capacity : 100,000 m^3/day

+. Dose : around 0.2 kGy

+. Expectation : Remove microorganisms over 99%
Reduction in Color, Odor etc.

+. Operates year-round

-. When combined with Bio-system, could be applicable to reduce T-N,T-P and residual organics.

Investment

items		Investment	Remark
Construction	Accelerator	2,000k$	400kW
	Facilities	1,000k$	Shield room
	Others	1,000k$	
Sub-total		4,000k$	
Area		150m^2	

Operation

Items	Annual Cost	Remark
1. Labor	100k$	
2. Electricity	320k$	800kW*0.05$/kWh*8000hr
3. Maintenance	80k$	
4. Interest	(320k$)	8%
5. Depreciation	(200k$)	20yrs
Total	500k$(520k$)	

Operation cost→ 500k$/[(100,000ton/day)*333day] = 0.015$/ton

Comparison with other AOPs etc.

	E-beam	UV	Ozone	Membrane
Investment (in Total)	high	medium low	medium	high
Operating cost (unit amount)	low	medium	medium	Medium high
Quality of treated water	good	good	good	excellent
Removal of microorganism	Excellent	good	good	?
Secondary waste	no	no	Un-reacted ozone	Concentrated waste
Advantage	easy operation fast processing	easy operation easy to scale-up	good to scale-up	good for small facility
Disadvantage	X-ray shield	-periodic change of lamp -scales on lamps -slow reaction	-mixing tools for dissolution -consumption of electricity (med.)	-consumption of electricity (high) -fouling problem in membrane

For the water with low contamination level

Cost analysis of EB & other processes

Technology	Ozone	Electron Beam(EB)	Ultraviolet (UV)
Flow		100,000m^3/day	
Capital Cost	7.4M$	4.0M$	2.4M$
Annual O&M Cost	1.2M$	0.5M$	1.0M$
Etc.			Lamp life : 1year Lamp p/u : $550

1. *Combined Sewer Overflow Technology Fact Sheet, Alternative Disinfection Methods [EPA 832-F-99-033] September 1999*
2. *Wastewater Technology Fact Sheet, Ultraviolet Disinfection [EPA 832-F-99-064] September 1999*
3. *1999 Drinking Water Infrastructure Needs Survey, Modeling the Cost of Infrastructure [EPA 816-R-01-005] February 2001*
4. *EB-TECH Report[2001]*

Conclusion

• A pilot plant with electron beam for treating 50m^3/day of unchlorinated secondary effluent from sewage wastewater plant has constructed and operated continuously since Feb. 2002.

• Electron beam treatment of sewage effluent shows advantages in removing microorganisms as well as an economical benefit when we operate with high power accelerators.

• Electron beam wastewater treatment shows good economies in investment and operation, and are promising for future wastewater treatment processes.

Thank You for your attention

Electron Beam Technology

WWW.EB-TECH.COM

Municipal Wastewater Treatment Plant in Daejeon

Characteristics

Area : 413,565m^2

Facilities : 41units in 20,634m^2

Capacity : 900,000m^3/day

Influent : 664,000m^3/day

하수처리 과정

하수관로

1 유입침사지
유입하수중에 있는 모래 및 잡쓰레기 제거

2 최초침전지
하수를 1차적으로 2시간동안 체류시켜 약 30%정도 오염물질 침전 제거

3 포기조
1차처리된 하수를 호기성 미생물을 이용하여 6시간 동안 반응처리

4 최종침전지
미생물에 의해 처리된 하수를 약3시간동안 체류시켜 슬러지를 침전, 깨끗한 상등수는 방류

방류

(침전찌꺼기)

(반송슬러지)

(잉여슬러지)

오니처리 과정

1. 농축조

수처리과정에서 발생되는 찌꺼기(슬러지)를 농축한 후 소화조로 이송

2. 소화조

혐기성 미생물을 이용 25~30일동안 반응처리하고 처리과정에서 발생되는 메탄가스는 소화조 가온용 연료로 사용

3. 탈수실

소화된 슬러지를 탈수기로 압축시켜수분제거후 반출

4. 슬러지 임시 저장소

탈수된 슬러지를 임시 저장한 후 차량을 이용하여 매립장으로 운반

슬러지운반
(매립장)