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Iran

Study of the Effects of Electron Beam on Heavy Metals in Presence of Scavengers for Decontamination and Purification of the Municipal and Industrial wastewater

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Research works undertaken

- **Microbiological treatments (water company, Ministry of energy)**
- **Decolorization (Textile Industries & wastewater company)**
- **Removal of heavy metals (water & wastewater company)**

Oxidation process usually used

- Use of ozone
- Hydrogen peroxide
- Ultraviolet

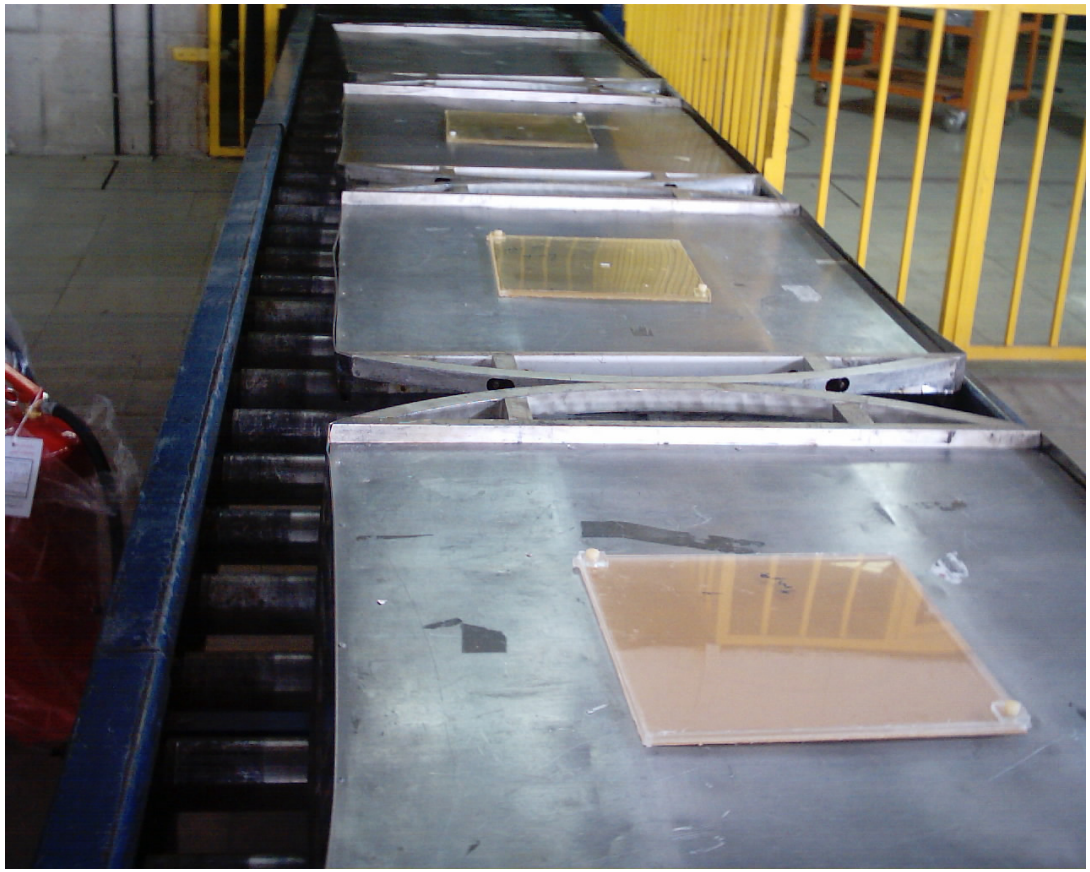
Advance oxidation process (AOP)

- Interaction of ionizing radiation with water
- Based on electron beam irradiation of wastewater (hydroxyl free radicals)
- Capacity to decompose the organic compounds

RHODOTRON TT200 electron beam accelerator parameters

Beam Energy	5 and 10 MeV
Beam power at 10 MeV	70 kW
Beam power at 5 MeV	35 kW
Energy dispersion at 10 MeV	±300 keV
Scanning range	30-100 cm
Total power consumption	≤ 300 kW
RF	107.5 MHz
RF power output	200 kW
Electron gun average current	0-10 mA
Resolution	±50 µA

Irradiation of the wastewater samples



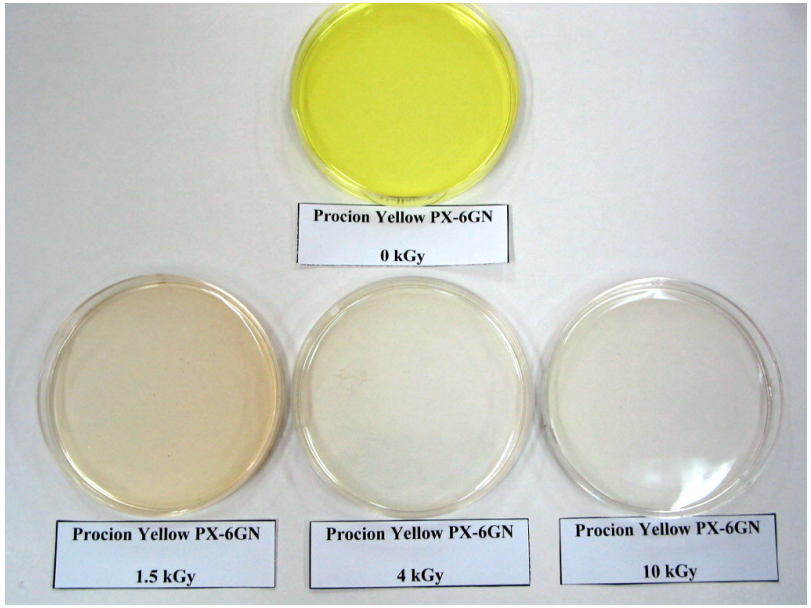
Wastewater irradiated by Electron beam

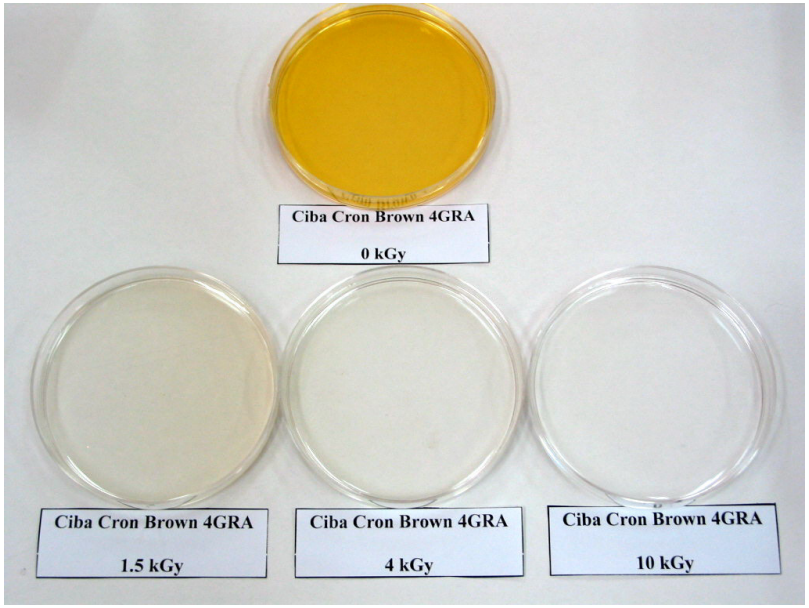
Wastewater samples before and after irradiation

Decolorization of dye molecules

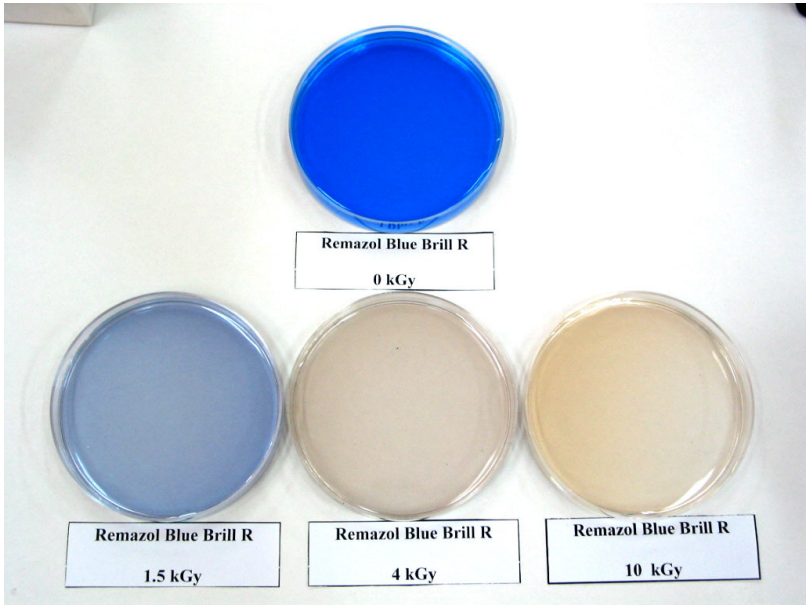
Reactive dyes irradiated by different doses

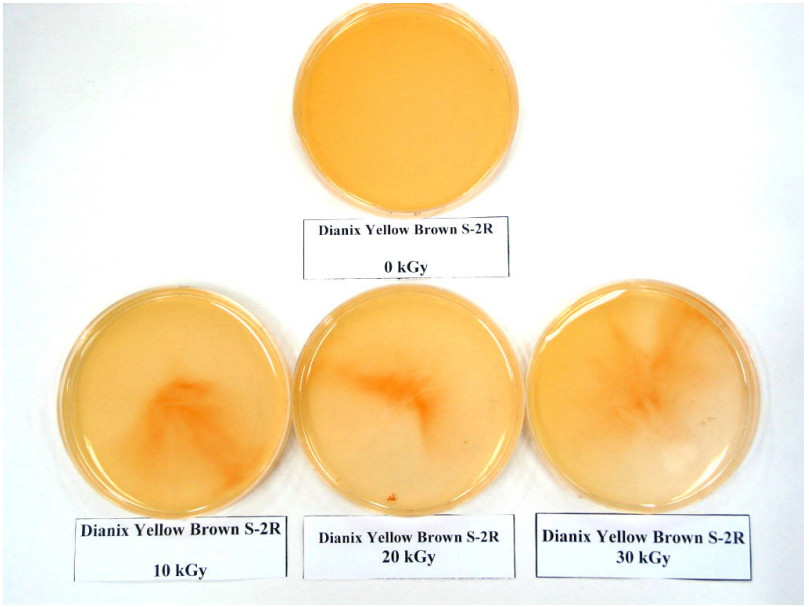
Irradiation of reactive dyes





Irradiation of disperse dyes



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EB Pilot Plant Control Panel
PILOT PLANT
OF WASTEWATER TREATMENT
BY ELECTRON BEAM
IAEA

Heavy Metals

- A common hazardous waste

  can damage organisms at low concentrations and tends to

  accumulate in the food chain.

- Examples are:

  Lead, Chromium, Cadmium, and Mercury.

Permitted level

element	Drinking Water mg/L	Natural Water and wastewaters mg/L	Water used in agriculture mg/L
Cd	0.005	0.01	0.01
Pb	0.05	0.05	5
Zn	3	5	2
Cu	0.05	1	0.2
Cr	0.05	0.05	0.1
Hg	0.001	-	-
As	0.05	0.05	0.1

Mechanism of radiolytic conversions of metal ions

$$Cd(II) + e_{aq} \rightarrow Cd(I)$$

$$Cd(II) + H \rightarrow Cd(I)$$

$$Cd(I) + Cd(I) \rightarrow Cd(0) + Cd(II)$$

$$nCd(0) \rightarrow Cd(0)_n$$

OH radicals

$$Cd(I) + OH \rightarrow Cd(II) + OH^-$$

$$Cd(I) + HO_2 + H^+ \rightarrow Cd(II) + H_2O_2$$

$$Cd(I) + H_2O_2 \rightarrow Cd(II) + OH + OH^-$$

Addition of OH absorber ($HCOO^-$)

format ions converte OH radicals (and H atoms) to COO^- radical ions

$$HCOO^- + OH(H) \rightarrow COO^- + H_2O(H_2)$$

$$Cd(II) + COO^- \rightarrow Cd(I) + CO_2$$

$$Cd(I) + COO^- \rightarrow Cd(0) + CO_2$$

Experimental procedure

- **Sample preparation**
- **Irradiation of the samples**
- **Determination of metal ions**

Sample preparation (I)

- **Methyl Mercury**
  CH_3HgCl
  and
- **Dimethyl Mercury**
  CH_3HgCH_3

Mercury

- **Methyl Mercury, (CH_3Hg)**

  Found in polluted water and wastewater

  (Most of the mercury in body)

- **Dimethyl Mercury, $Hg(CH_3)_2$**

  Found in polluted air and soil

Sample preparation

Decomposition and recovery of methyl and dimethyl mercury

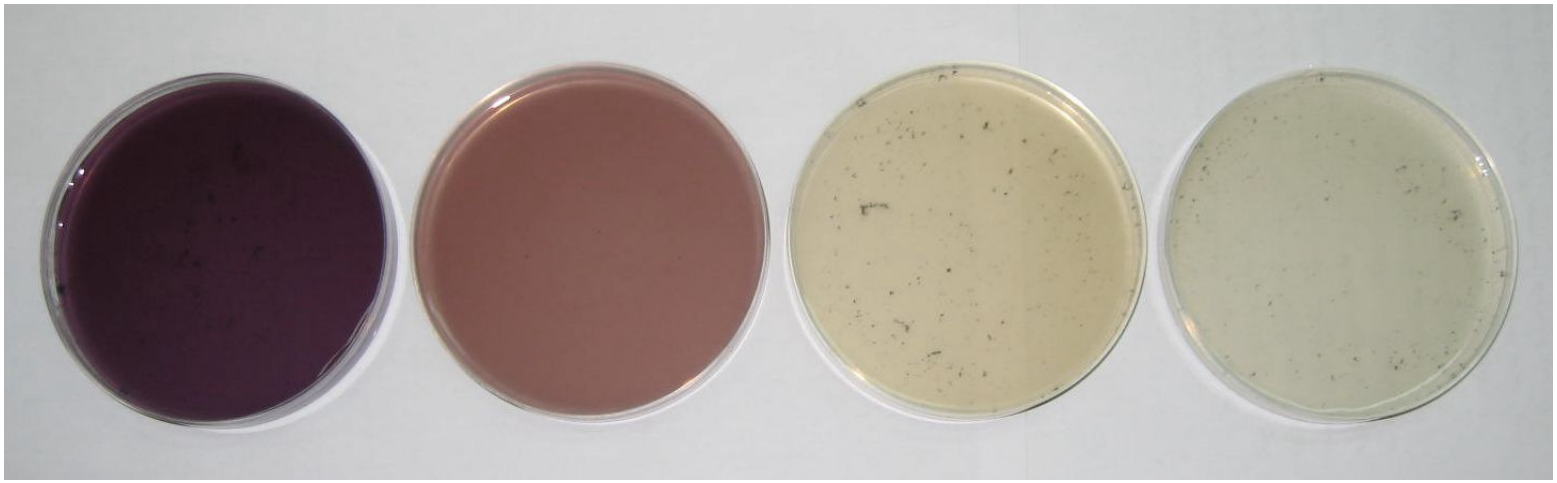
Organic mercury	1 kGy	3 kGy	5 kGy
CH_3HgCl	47.1 ± 3 .3%	70.9 ± 3.3%	98.2 ± 2%
CH_3HgCH3	10 ± 2.9%	15.5 ± 3.3%	20.3 ± 3.3%

Sample preparation (II)

- 1) **Wastewater from stabilizing ponds:**
  - A) influent wastewater (Mixed)
  - B) effluent wastewater
- **2) Effluents from textile industry**
- **3) Water solution spiking 100 ppb Cd or Pb**

Yazd wastewater stabilizing ponds

Textile effluents irradiated (different dose)



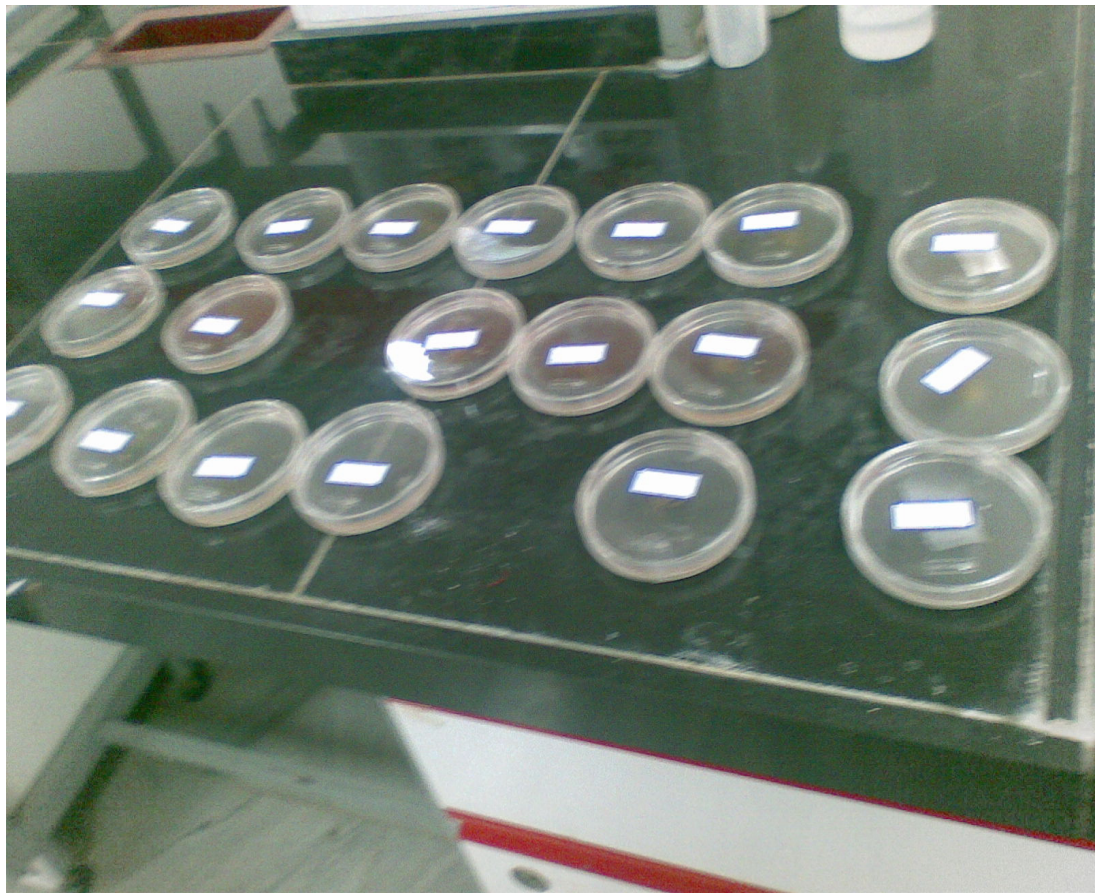
40 ml of solution in Petri dishes

Electron beam irradiation

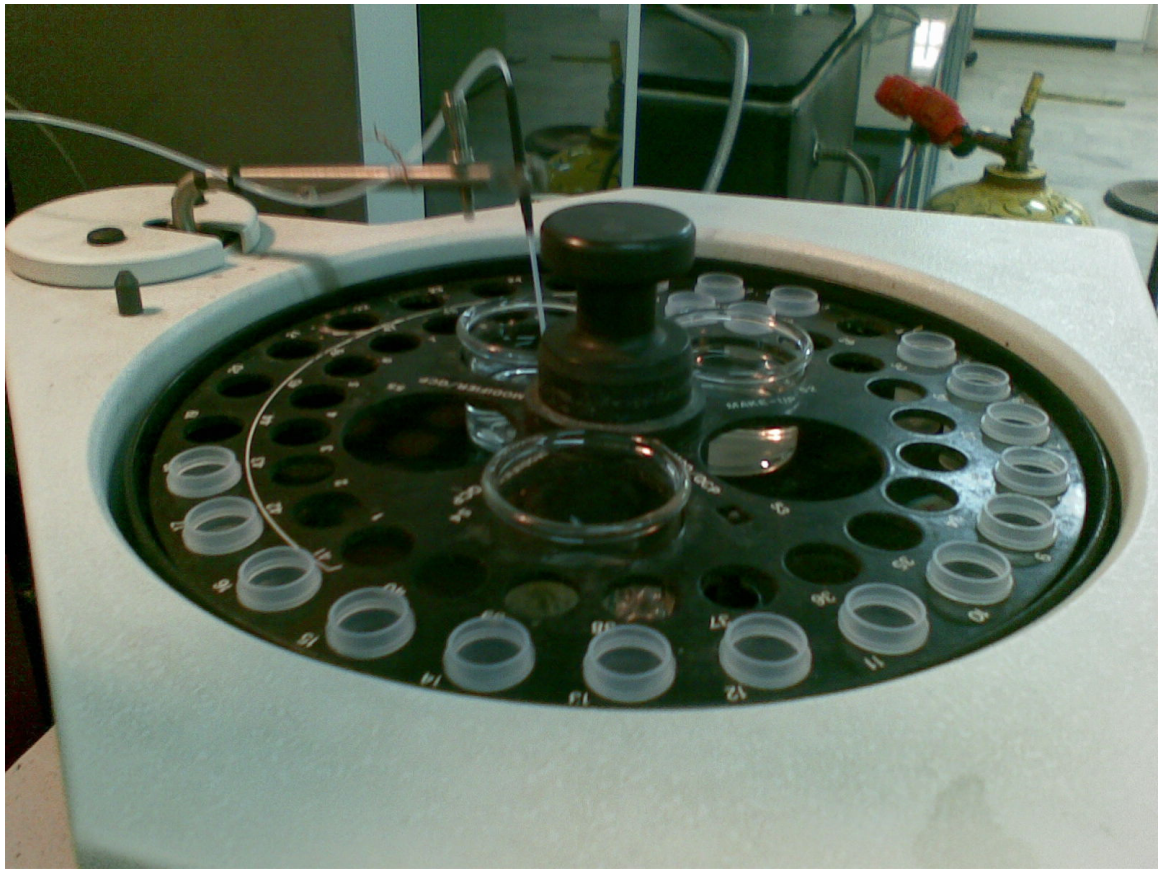
- **Absorbed Doses:**

1 kGy
3 kGy
6 kGy
9 kGy

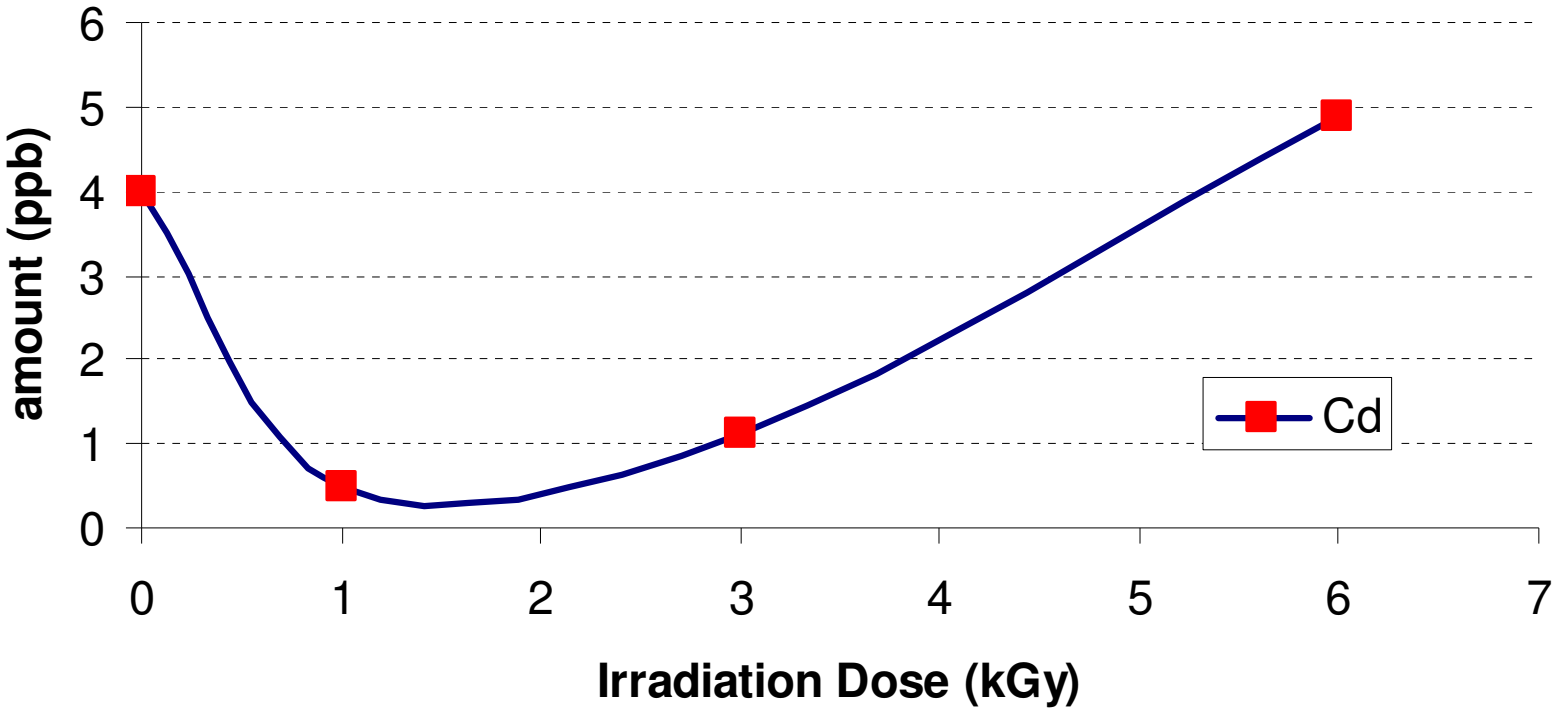
Irradiated samples ready for metal determination



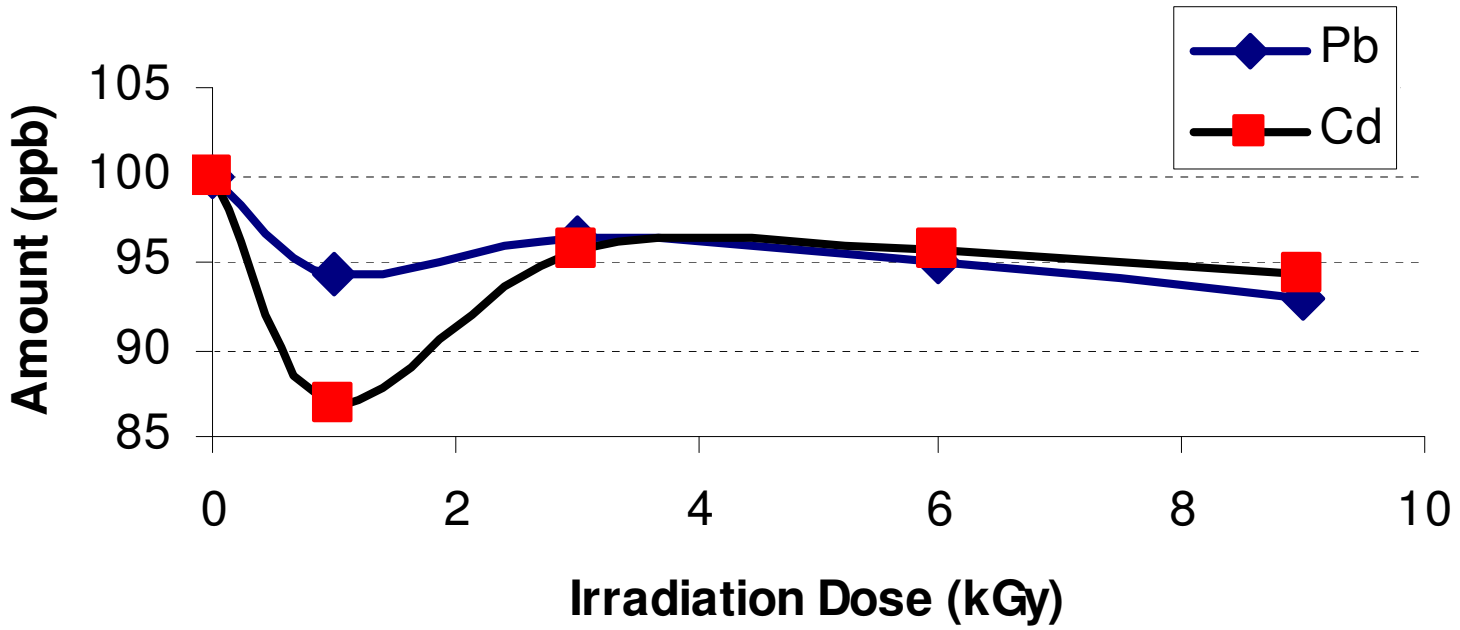
Determination of metal ions by Furnace Atomic Absorption Spectrometer



Irradiation of raw influent



Laboratory made samples

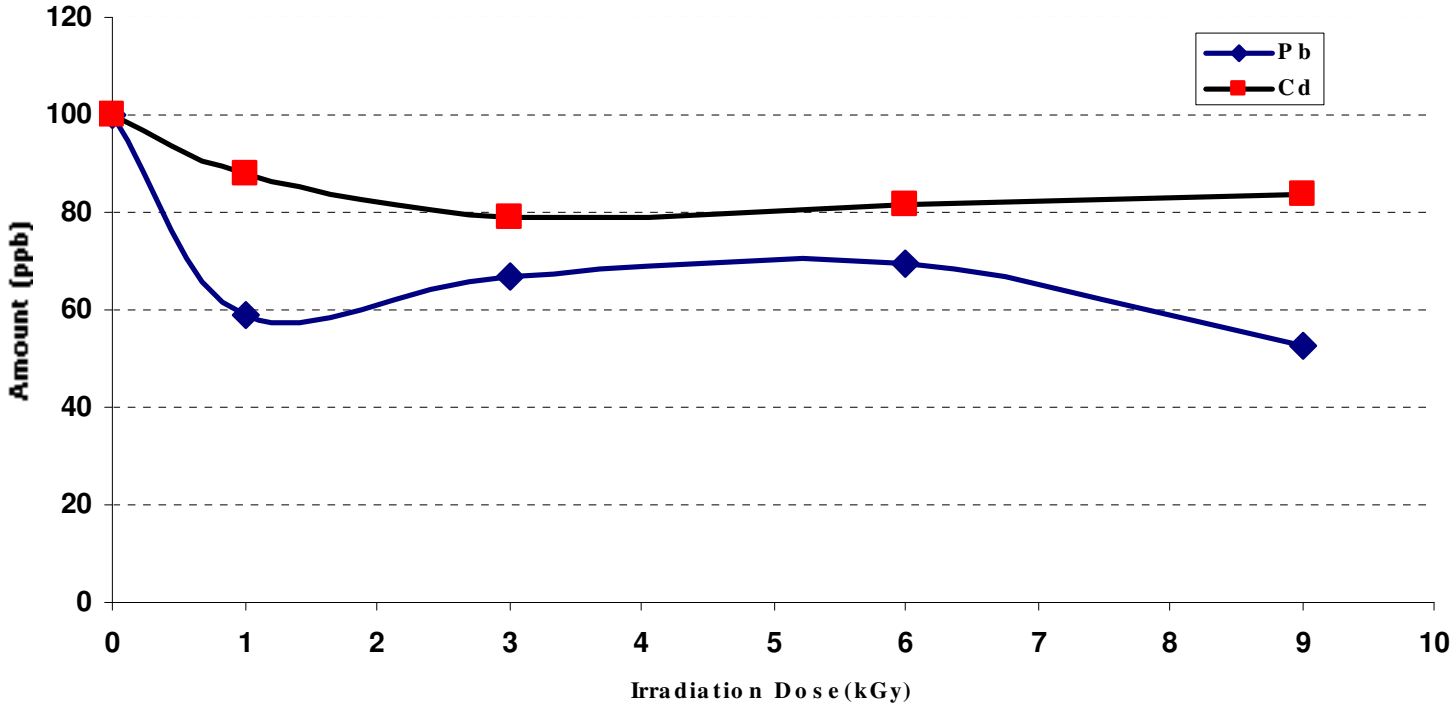


Addition of scavengers

- Rice bran
  size <200 micron
  as a natural sorbent.

- 4, 8, and 12 mg

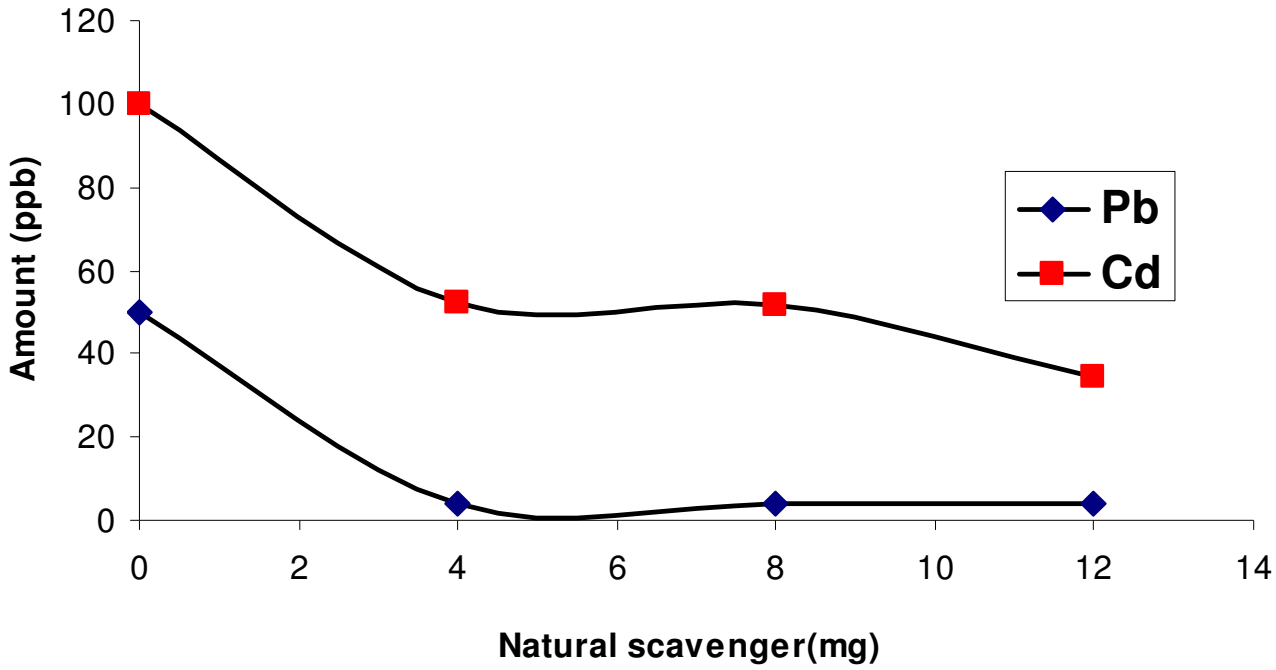
Irradiation of samples by adding 4 mg natural scavenger



Irradiation of the samples with different amounts of scavenger

Cd (ppb(	Pb (ppb (	Scavenger (mg)	Absorbrd Dose (kGy)
100	100	-	0
86.8±1.7%	94.2±0.5%	-	1
95.8±6%	79.3±6.3%	-	3
95.7±1.8%	95.1±7.8%	-	6
94.3±4.3%	93.0±5.4%	-	9
87.8±2.6%	59.1±4.8%	4	1
79.1±2.3%	67.0±5.1%	4	3
81.8±5.8%	69.5±3.5%	4	6
83.7±4%	52.5±4.9%	4	9
79.8±6.1%	51.5±0.3%	8	9
82.2±5.6%	34.3±8.9%	12	9

Adding natural scavenger (+9 kGy)



Water samples containing Cd and Pb and EDTA (0.001 molar)

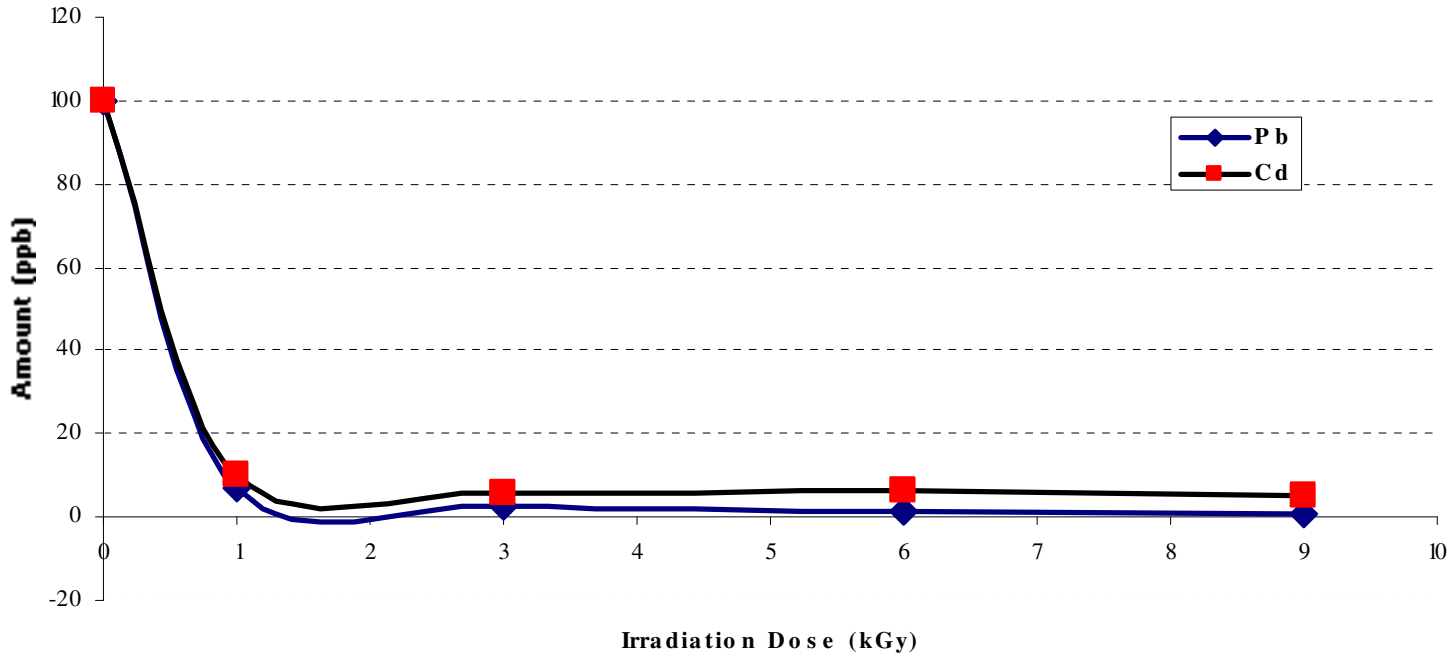
Cd (ppb)	Pb (ppb)	Scavenger (mg)	Absorbed Dose (kGy)
100	100	----	0
48.3±5.3%	34.0±1.7%	12	1
47.3±3.8%	31.9±7.6%	12	3
38.1±6.3%	25.4±0.2%	12	6
47.6±2.6%	27.0±10%	12	9

Irradiation of samples containing Cd and, Pb and Sodium acetate (NaCH3COO, 0.001 Molar)

Cd (ppb)	Pb (ppb)	Scavenger (mg)	Absorbed Dose (kGy)
100	**100**	**0**	**0**
10.1±0.4%	7.3±0.8%	**12**	**1**
5.9±2.9%	2.6±5.5%	**12**	**3**
6.4±0.1%	1.1±12.2%	**12**	**6**
5.4±0.5%	0.8±15.1%	**12**	**9**

Addition of $NaCH_3COO$

- As a chemical reagent

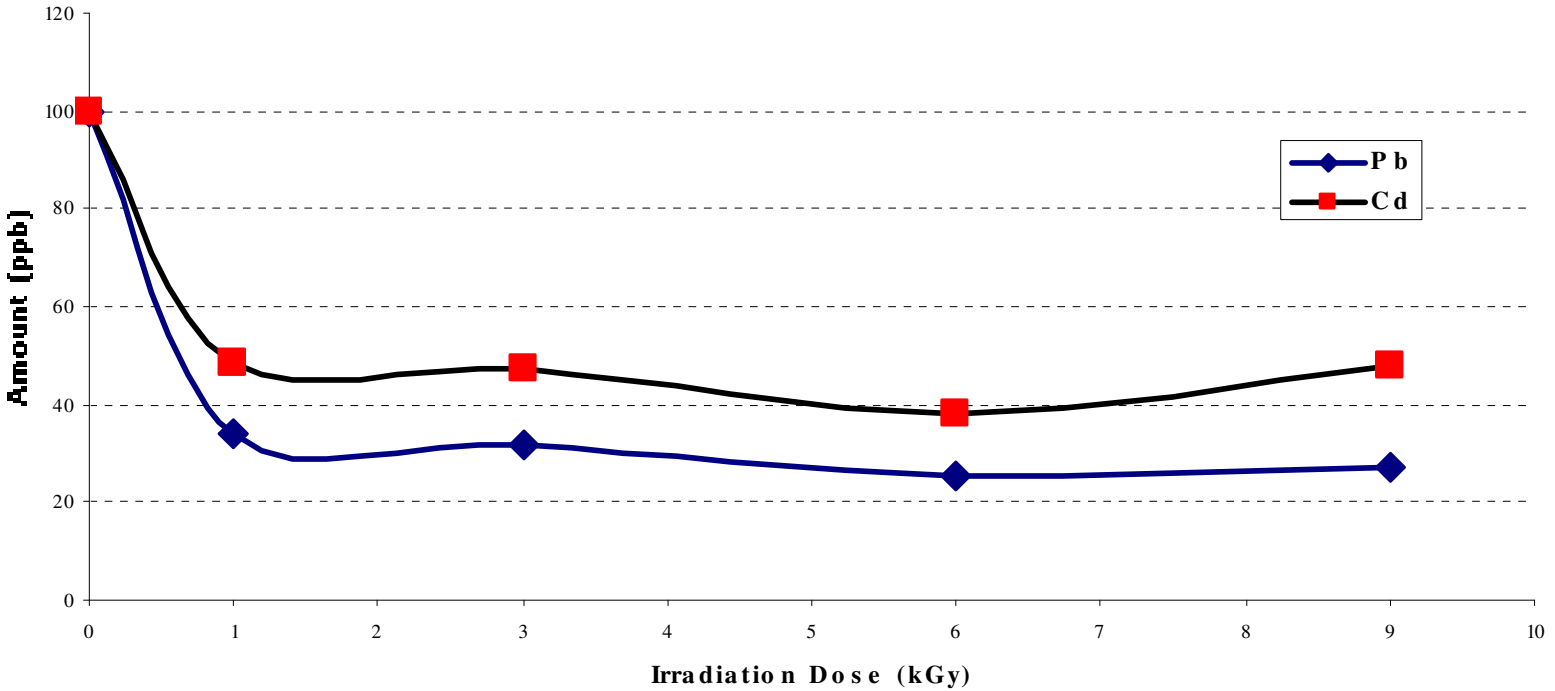


Irradiation of samples containing Cd and Pb and EDTA (0.001 Molar) with and without scavenger

Cd (ppb)	Pb (ppb)	Scavenger (mg)	Absorbed Dose (kGy)
100	**100**	**----**	**0**
48.3±5.3%	34.0±1.7%	**12**	**1**
47.3±3.8%	31.9±7.6%	**12**	**3**
38.1±6.3%	25.4±0.2%	**12**	**6**
47.6±2.6%	27.0±10%	**12**	**9**

Addition of EDTA

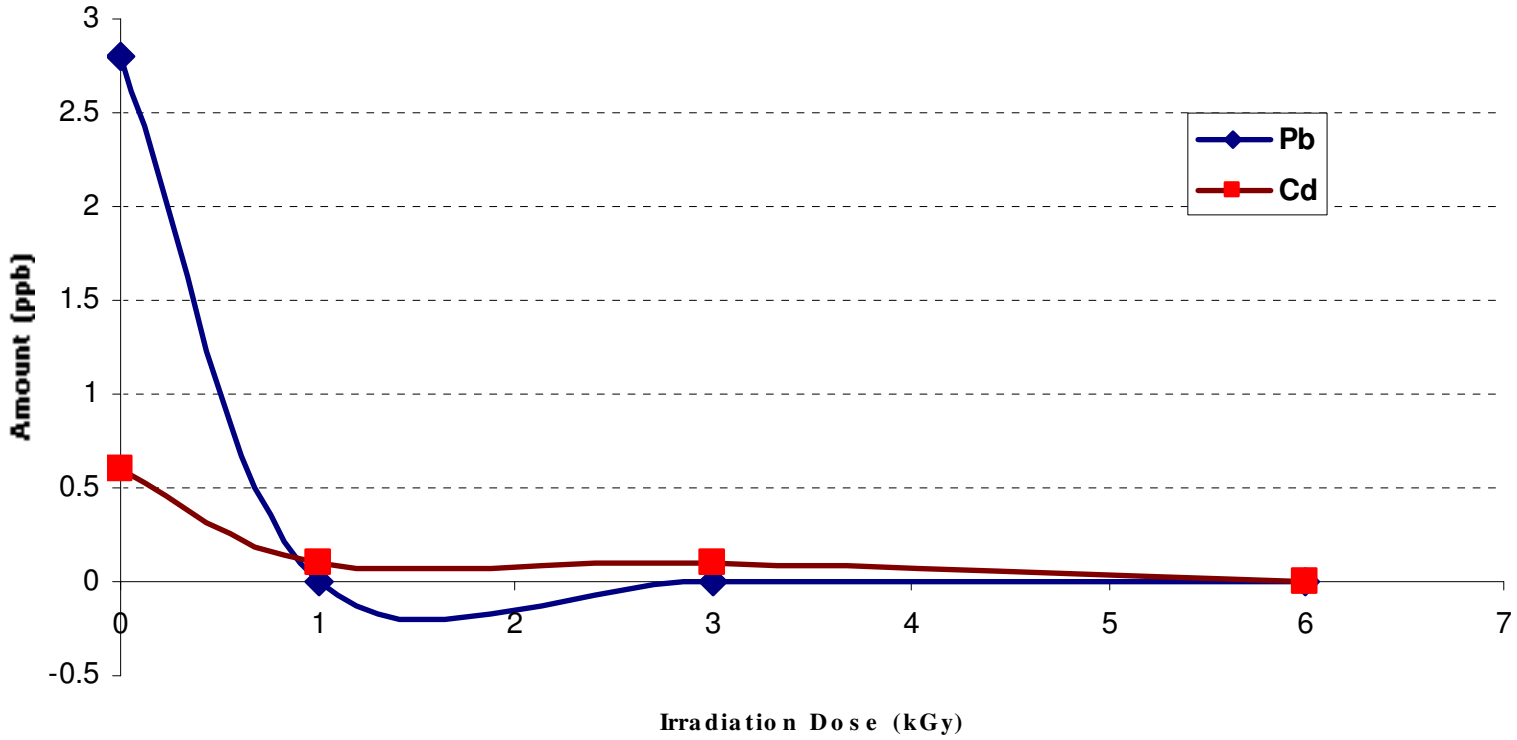
- Chemical complexing agent



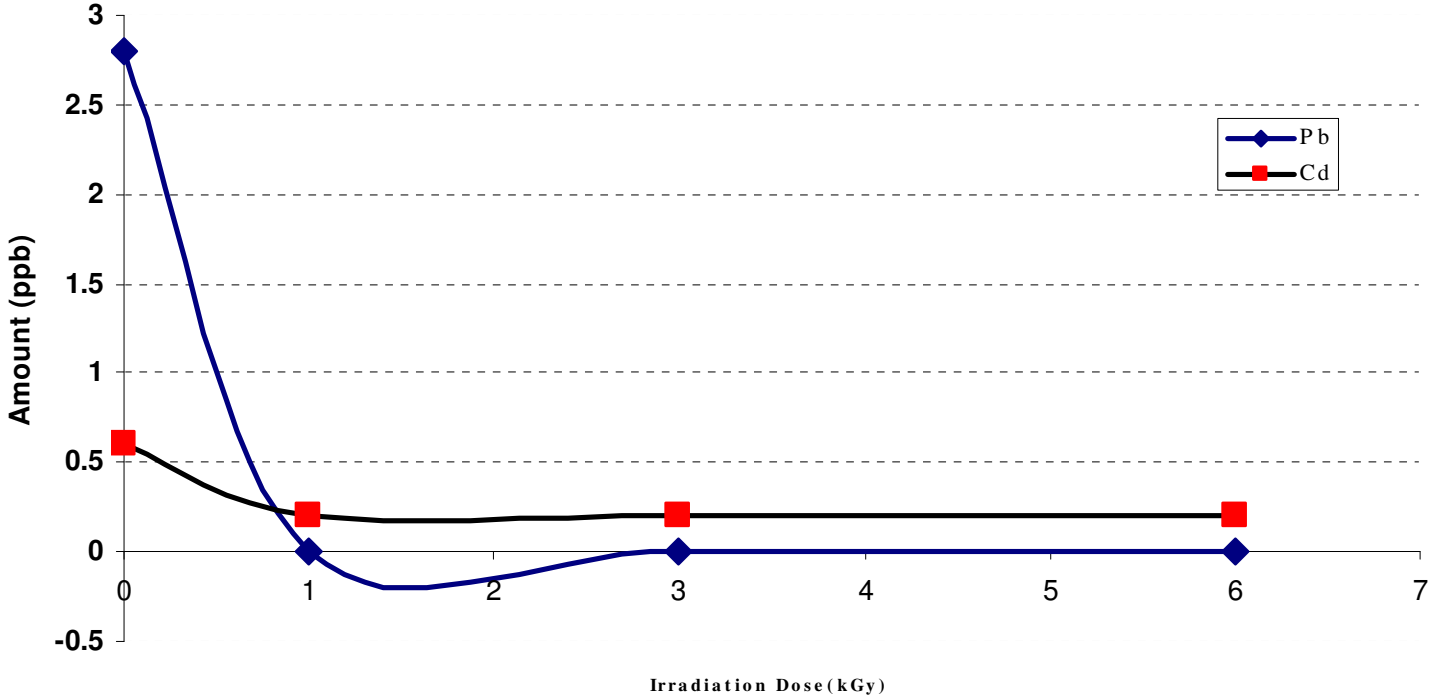
Irradiation of effluent from wastewater plant

Cd (ppb)	Pb (ppb)	$NaCH_3COO$ Or EDTA	) Scavenger ( ) mg)	Irrradiation Dose (kGy(
0.6	2.8±2.2%	-	--	0
0.1±18.9%	N.D.[1]	$NaCH_3COO$	12	1
0.1±8.7%	N.D.	$NaCH_3COO$	12	3
------	N.D.	$NaCH_3COO$	12	6
0.2±0.3%	N.D.	EDTA	12	1
0.2±3.6%	N.D.	EDTA	12	3
0.2±44.3%	N.D.	EDTA	12	6

Irradiation of effluent from wastewater plant +$NaCH_3COO$+12 mg scavenger



Irradiation of effluent from wastewater plant +EDTA+12 mg scavenger



Conclusion

- Electron beam irradiation of water and wastewater samples can increase the concentration of free metal ions in the samples.
- natural scavenger together with EB radiation can increase the heavy metal removal from the wastewater samples.
- capability of the natural scavenger in the presence of chemical agents is increased.

Thank you for your attention