Third Technical Meeting (TM) on the Environmental Modelling for RAdiation Safety

EMRAS II
Intercomparison and Harmonization Project

IAEA Board Room (Room A, M Building), IAEA Headquarters, Vienna

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Overview of Legacy/NORM sites in Bayan Obo and Baotou, Inner Mongolia, China

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1. Sites description

Inner Mongolia **B**ao**T**ou **I**ron and **S**teel **P**lant (Group Ltd.)

or **BTISP**

founded in 1954

- **Bayan Obo**
  - **Mining and crashing**
  - **Milling (2008,one pipe for water, another for concentrated slurry)**
- **Baotou**
  - **Iron and Steel Plant**
  - **Rare earth plants (1974)**

Inner Mongolia **B**ao**T**ou **I**ron and **S**teel **P**lant (Group Ltd.) or **BTISP**

- **9×10^6 t/a products of iron and steel**
- **more than 7×10^3 t/a products of oxide equivalent of REO (**2006**).**

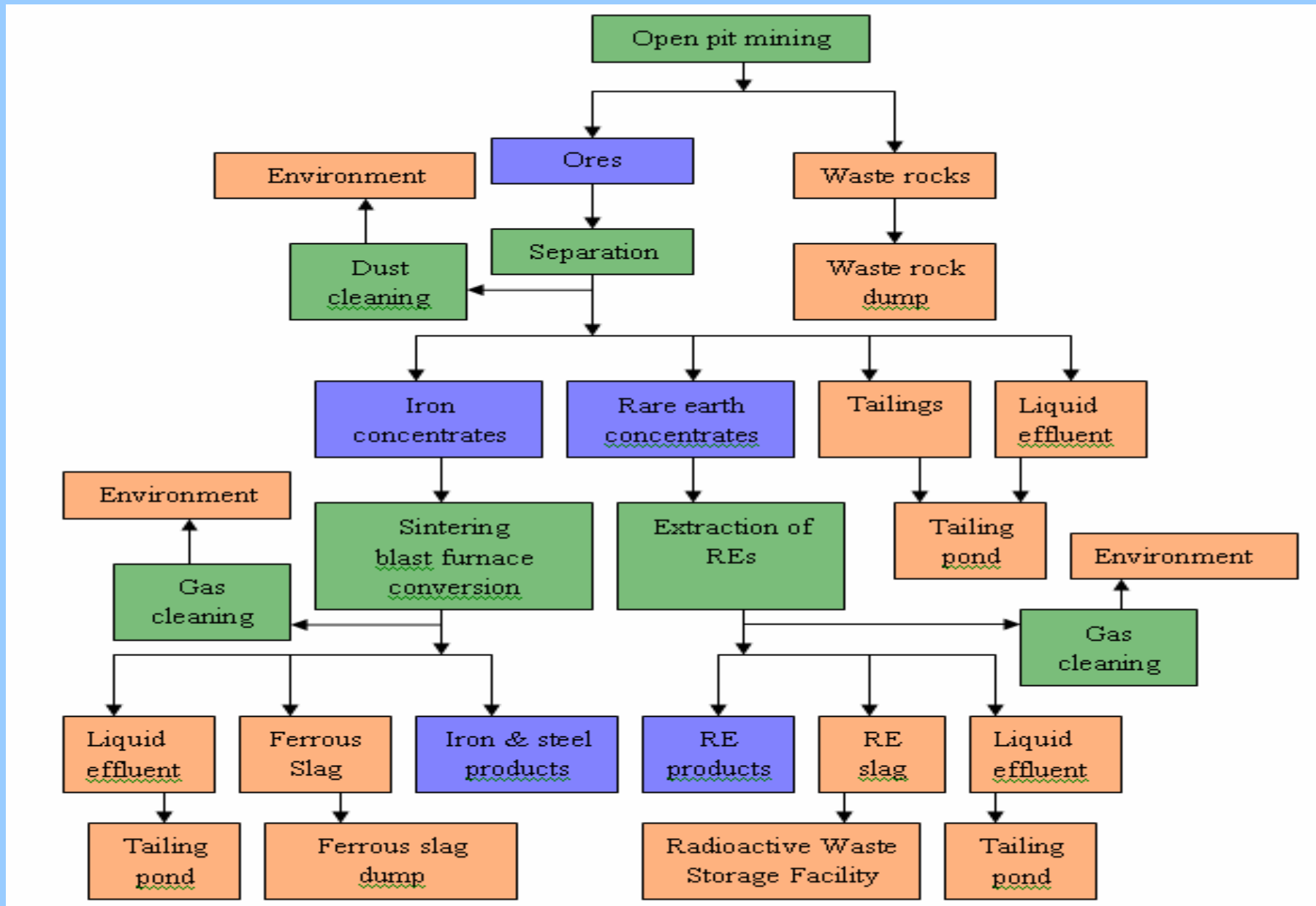
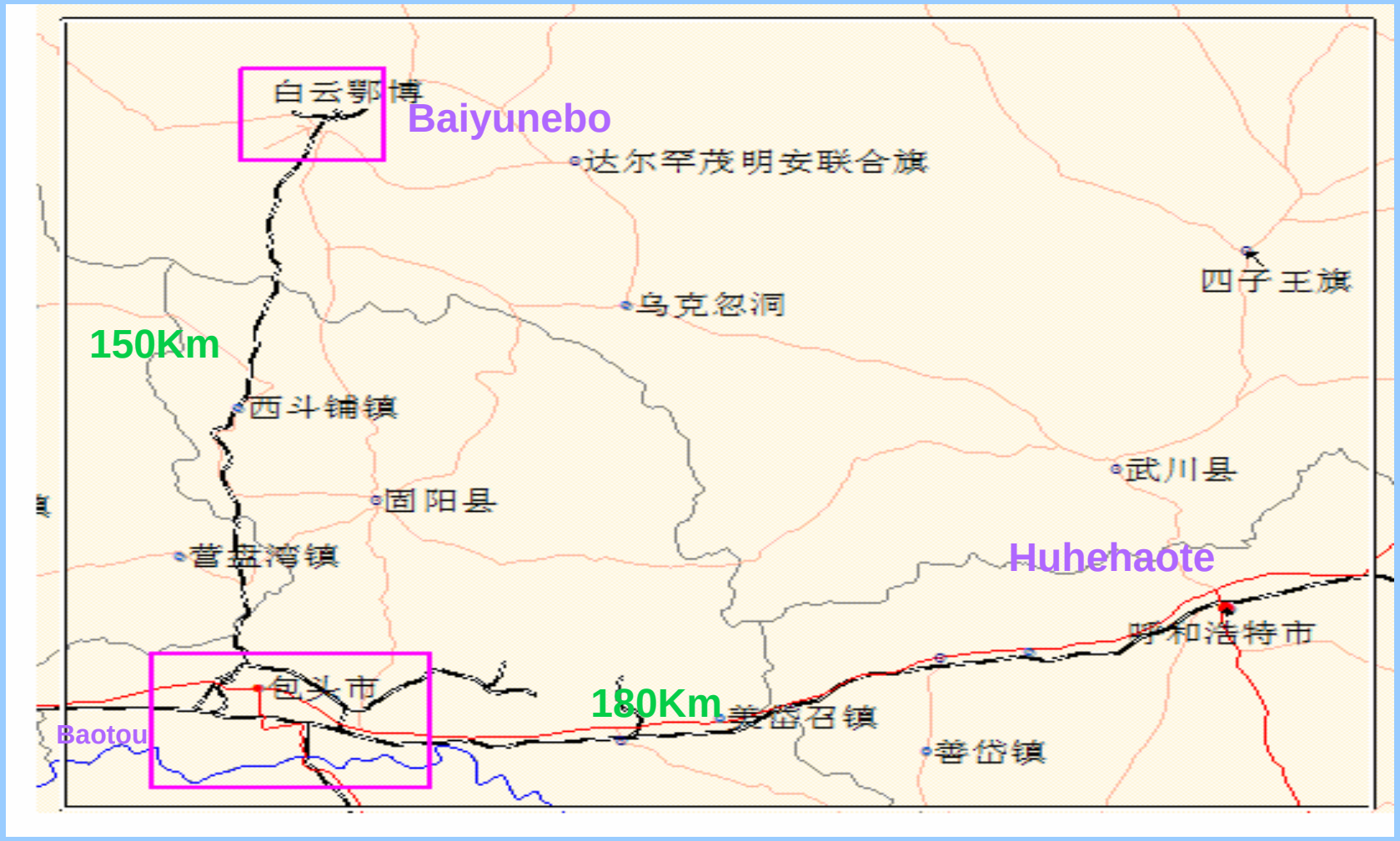
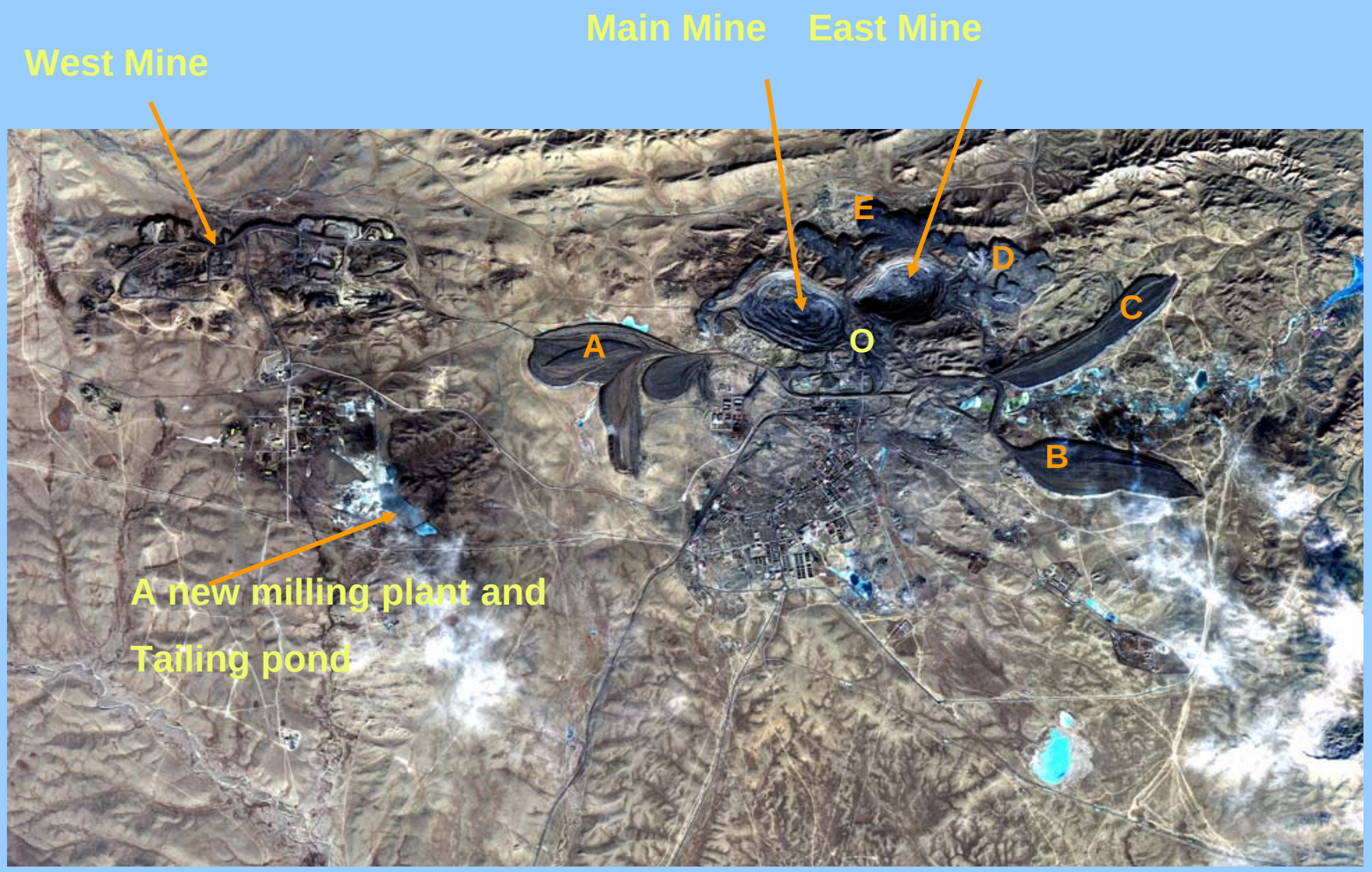


FIG 1. Major flow chart and pollutant production of Bayan Obo ores exploitation


白云鄂博
Baiyunebo
达尔罕茂明安联合旗
四子王旗
乌克忽洞
150Km
西斗铺镇
武川县
固阳县
营盘湾镇
Huhehaote
呼和浩特市
包头市
180Km
美岱召镇
Baotou
善岱镇



Bayan Obo Mining Sites
Ores (O),Dumping sites(A,B,C,D,E)

Mining sites in Bayan Obo

•Main Mine and East Mine

open pit mines

1520×1080m^2 for Main Mine, 1400×1020m^2 for East Mine

About 10×10^6 t/a of ores are recently mined
About 276×10^6 t of ores had been mined by the end of 2006.

Mining sites in Bayan Obo

•West Mine

a big open pit mine, started in May, 2006.

4,600 m in length
1,000 m to 1,200 m in width.
The present production of ores is expected to be 3×10^6 t/a,

Mining sites in Bayan Obo

- **waste rock dumps**

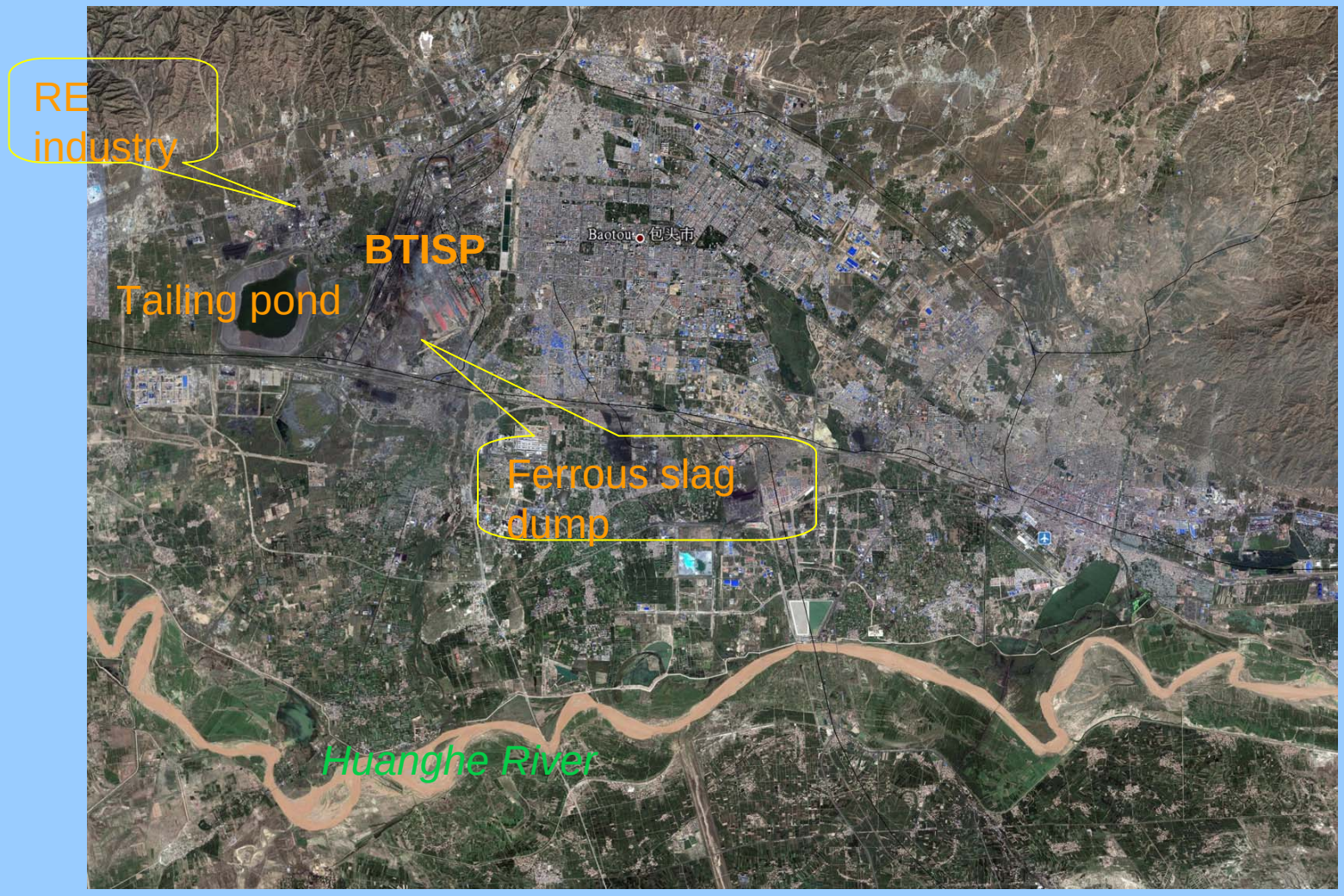
About 10×10^6 t of waste rocks are produced annually.

Total amount of waste rocks is about 560×10^6 t , piled up in the waste rock dumps.

A new milling plant and

tailing pond has
operated since 2005.

The BTISP and Baotou City



Refining

iron and steel

RE Processing

RE oxides, RE chlorides,
RE carbonates and alloy products

Tailings , 149 ×10^6 t , 2006
an area of 11km^2
6.55×10^6 t/a with 0.048% Th

ferrous slag, 3.55×106 t/a
1km^2

acidic process slag ,60×10^3 t/a , gross α , n×10^{5}Bq/kg, in Radioactive Waste Storage Facility

brickyard

about 1450,000 t/a of ferrous slag has been used to make cement, bricks and other building products

Recovery of iron

2. Monitoring programme

2. Monitoring programme

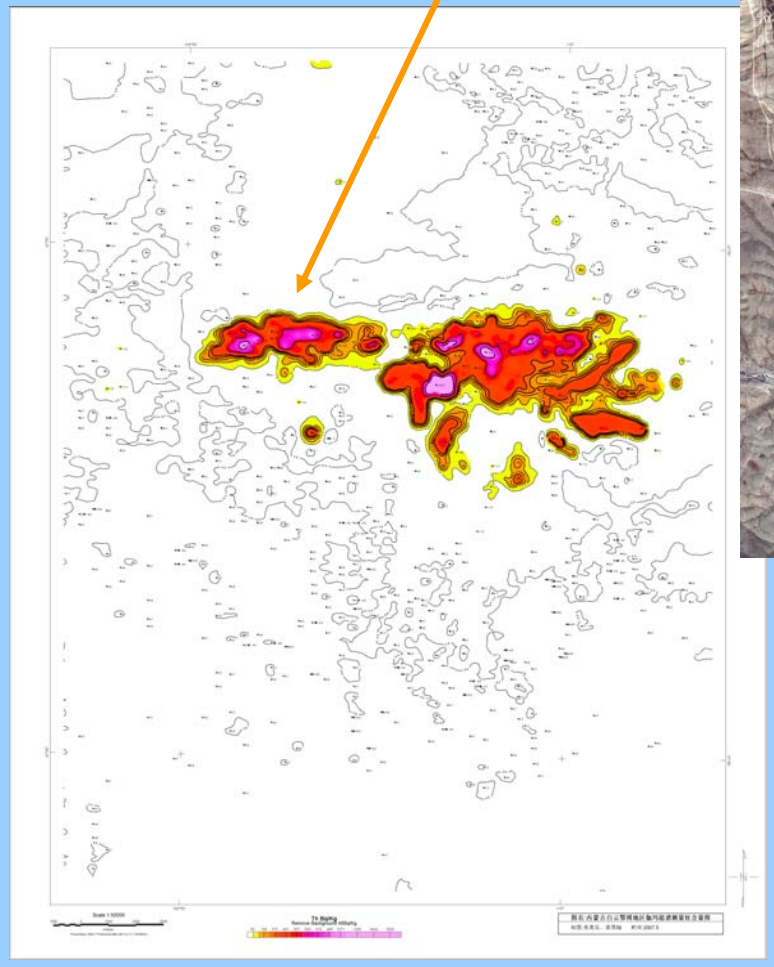
- **Regional Radiological data**

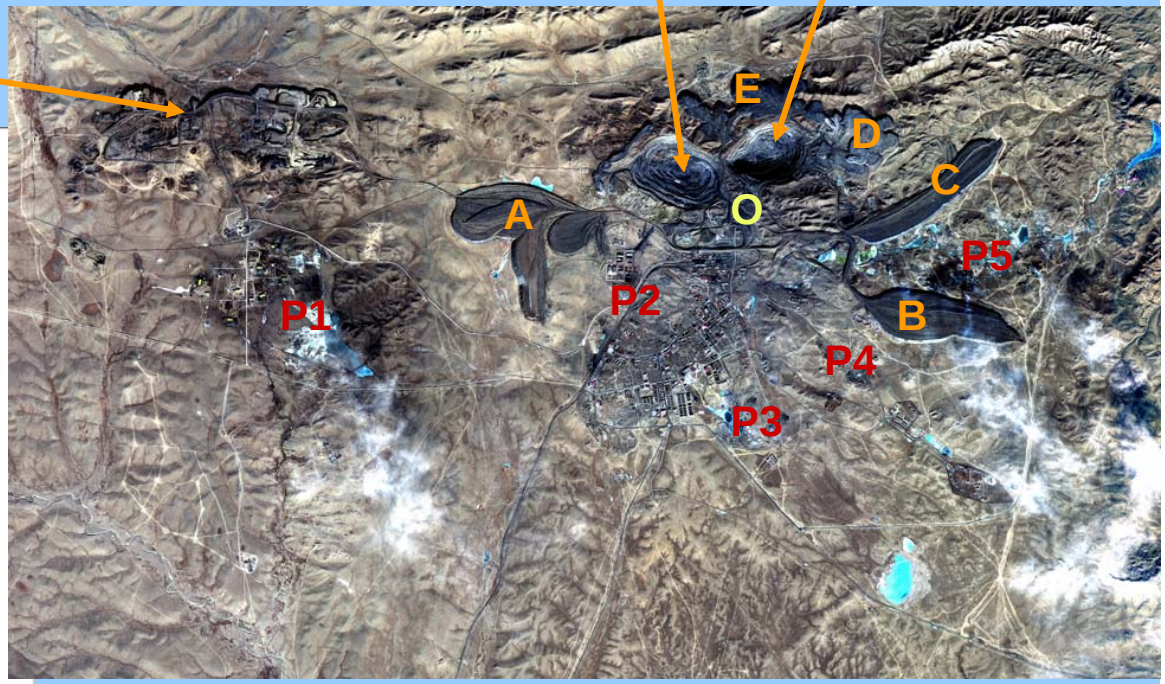
  Aero survey and ground measurements
  Work was done during 2006-2009

- **Monitoring data**

  The Monitoring Data of Baotou Radioactive Environmental Quality , required by regulation, and carried out by INNER MONGOLIA RADIOACTIVE ENVIRONMENT MANAGEMENT INSTITUTE

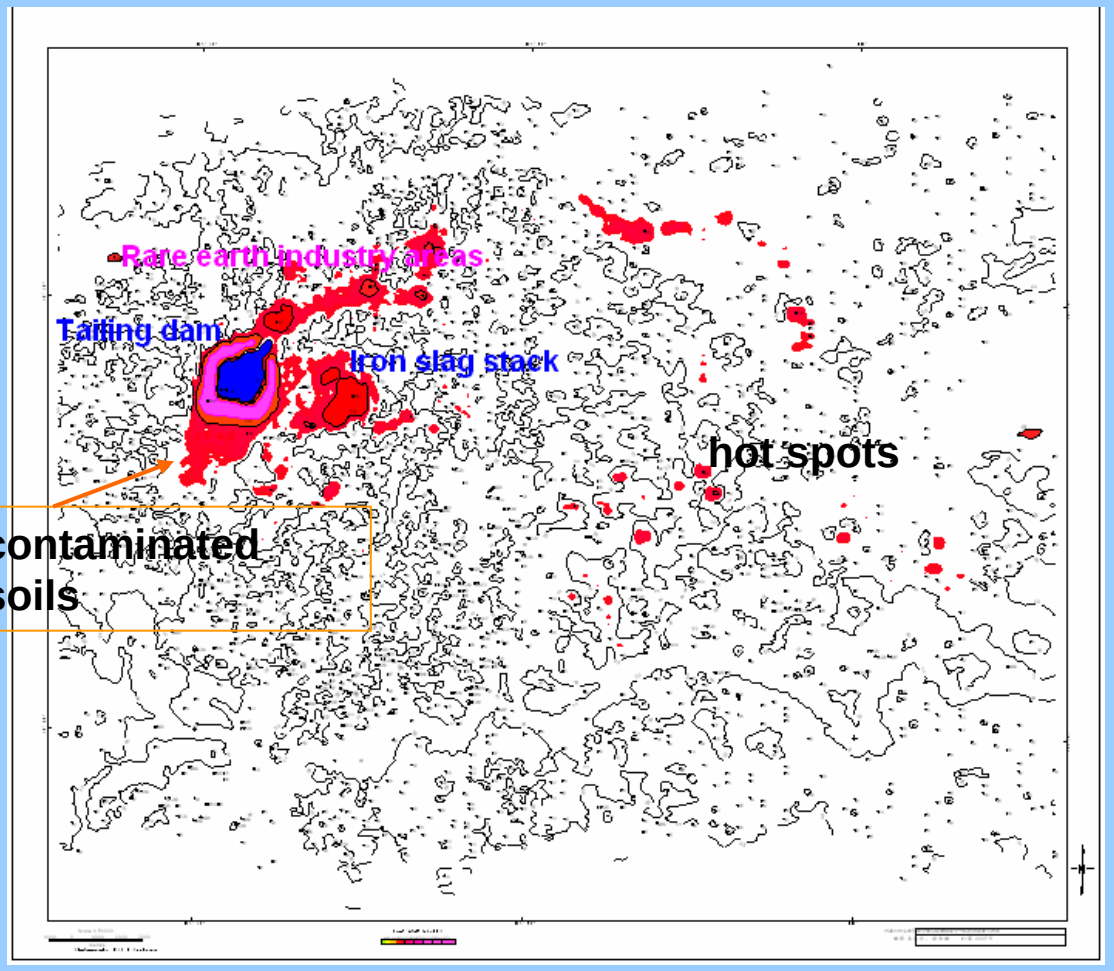
sites with elevated levels of radioactivity





BG: 85nGy/h
HBG:200—800nGy/h (about 55.4 Km^2)
Mining sites and Ores (O):600 to 2000nGy/h
Dumping sites(A,B,C,D,E): 400 to 800nGy/h
1200nGy/h
hot spots (P1-5): 500-2000nGy/h

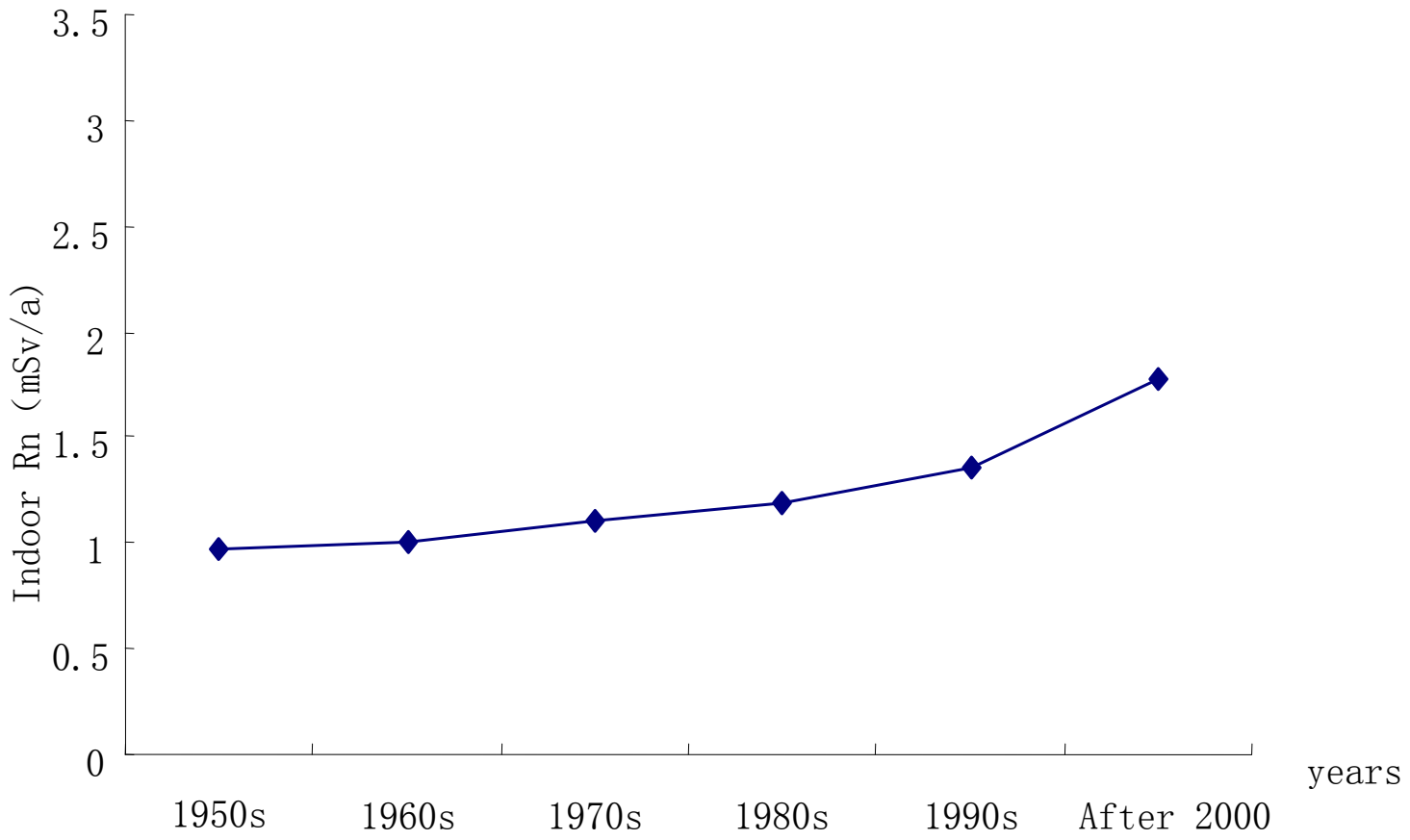
sites with elevated levels of radioactivity



BG: 65nGy/h (50Bq/Kg for Th)
Tailing pond: 650-1200 nGy/ h (11 Km^2)
Ferrous slag dump: 500-1200 nGy/ h
The contaminated soil area:
85-150nGy/h
80-200Bq/kg for Th in the upper layer of 10 -20cm.
32 hot spots : 120-1200nGy/h

Indoor radiation	PAEC of ^{222}Rn progeny	PAEC of ^{220}Rn progeny	**Gamma dose rate**
	nJ/m^3	nJ/m^3	E-8Gy/h
BS	212.5	186.25	16.12
BNS	**60.86**	**37.78**	**12.63**

BS-the buildings made of slag bricks.
BNS-the normal buildings not containing slag



Indoor radiation of buildings built in different years

3. dataset available for modelling

Ferrous slag produced in defferent years

years	^{226}Ra Bq/kg	^{232}Th Bq/kg	^{40}K Bq/kg	I_{Ra}	I_{γ}
before1990	95.1±24.5	2072.6±254.1	236.2±75.2	0.48	8.28
1992	82.9±13.3	1618.2±194.2	341.0±64.8	0.41	6.53
1993	81.9±12.3	1233.6±148.0	274.9±55.0	0.41	5.03
1993	101.9±16.3	1327.0±159.2	187.2±18.8	0.51	5.42
1996	105.8±15.3	612.0±108.2	132.2±15.6	0.53	2.67
2003	90.9±6.3	588.1±41.3	112.9±7.9	0.45	2.53
2005	119.5±8.3	529.2±16.3	154.7±6.9	0.60	2.40
2006	106.1±9.6	536.6±24.3	169.3±16.3	0.53	2.39
2007	120.6±20.6	516.4±66.9	211.3±41.1	0.60	2.36
2008	75.9±10.8	426.6±52.2	153.6±27.8	0.38	1.88

Building material in Baotou

products	^{232}Th Bq/kg	^{226}Ra Bq/kg	^{40}K Bq/kg	I_{Ra}	I_r
Brick1 factory1	180±17.2	45±3.4	210±24.1	0.23	1.18
Brick2 factory1	212±22.5	51±2.5	123±17.8	0.25	0.98
Cement1 factory 2	39.0±2.7	35.5±2.8	122±9.0	0.18	0.27
Cement2 factory 2	209.8±12.1	58.9±2.7	192.2±12.3	0.29	1.01
Cement3 factory 2	240.1±21.7	24.6±1.2	371.9±12.4	0.12	1.08
Cement factory3	330.9±32.4	83.6±8.7	429.2±32.7	0.42	1.60
Brick factory4	192±12.6	56±2.1	402±32.1	0.28	0.99

Typical ranges of radiation level in work places and environment

Type of samples	*Gamma dose rate nGy/h	**PAEC of ^{220}Rn progeny Mev/l
Bayan Obo background	85	
Mining sites	600-2000	
Dumping sites	400 to 800	226.1
Work places in plants	300-500	
Bayan Obo City area	100 -150, average 121	199.4
Background in Baotou	65	
Work places in plants	Mostly,300-500; Some,500-1000,max 1518	25-500 (average 126)
Taillings	650-1200	75.4-590.1 (average 243)
RE slag pile	1500-4000	
Contaminated soil in Baotou	85-150	
Baotou City	Background	69-125.6 (average 94)

*PAG- data after the Programme of Aero survey and ground measurements

**MIMRE- data after the results of Monitoring by Inner Mongolia Radioactive Environment Management Institute

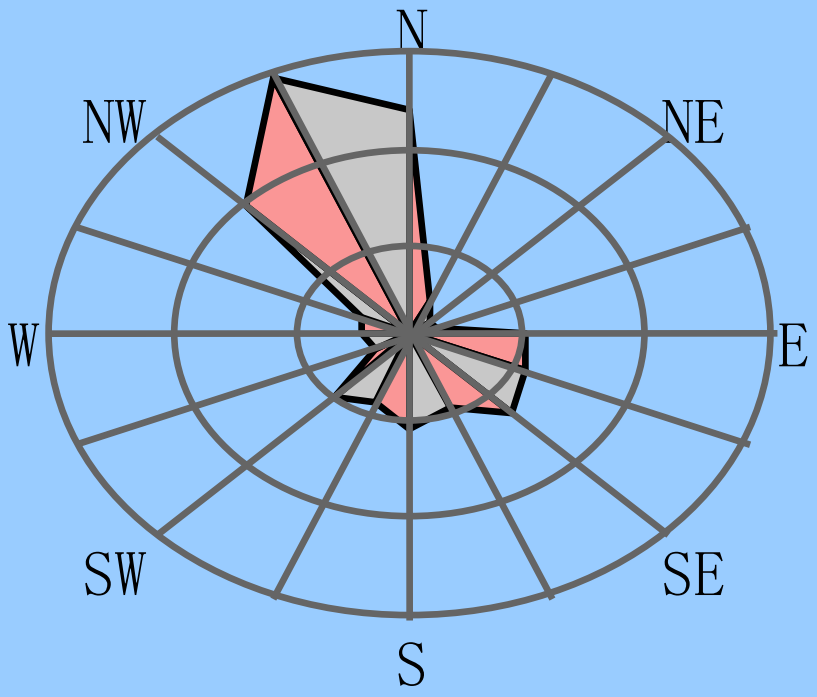
Typical ranges of radionuclide concentration in environmental materials

Type of samples		units	^{226}Ra	^{232}Th	^{228}Ra	
Soil background in Bayan Obo		Bq/kg	33	46		PAG
tailings				about 1600		PAG
ferrous slag		Bq/kg		$0.5\text{-}1.6\times10^{3}$		PAG
RE slag		Bq/kg		$2.0\text{-}3.8\times10^{3}$		PAG
contaminated soil(upper layer 10 cm) in Bayan		Bq/kg		80-120		PAG
dust powder from	crushing and sorting plant	Bq/kg		$1.3\text{-}1.9\times10^{3}$	$1.2\text{-}2.0\times10^{3}$	MIMRE
	sintered plant	Bq/kg		$0.5\text{-}1.6\times10^{2}$	$1.2\text{-}2.0\times10^{2}$	
	steel smelting plant	Bq/kg		$0.2\text{-}1.2\times10^{2}$	$0.2\text{-}1.1\times10^{2}$	
exhaust gas from RE plant		10^{-2} Bq m^{-3}		3.2		MIMRE
Soil background in Baotou		Bq/kg	33	36		PAG
contaminated soil(upper layer 20 cm) in Baotou		Bq/kg		80-200,or>400 near tailing pond		PAG

*PAG- data after the Programme of Aero survey and ground measurements

**MIMRE- data after the results of Monitoring by Inner Mongolia Radioactive Environment Management Institute

Meteorology



Wind rose

Sea-son		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	C
S	freq.	6.10	1.30	1.20	1.30	7.00	9.80	12.10	6.00	6.50	5.00	3.00	1.30	1.00	0.60	5.00	7.00	15.6
	speed	2.70	3.30	1.60	3.50	2.40	2.60	2.70	3.40	3.00	2.30	2.40	2.70	1.80	4.50	3.00	3.10	
SP	freq.	10.00	1.10	1.00	0.80	1.80	3.00	3.50	2.60	5.00	3.10	5.20	3.80	3.80	5.00	12.60	15.00	23.30
	speed	7.20	4.00	2.00	2.00	2.20	4.80	4.05	3.20	4.10	4.80	4.00	7.20	5.20	6.40	5.60	5.90	
F	freq.	19.50	3.00	2.50	0.60	2.80	2.70	3.00	2.50	3.20	3.10	4.80	2.50	3.00	10.00	15.00	19.00	19.10
	speed	4.00	2.35	2.80	2.40	2.50	2.40	4.00	4.40	4.40	3.60	3.60	2.40	4.20	4.00	4.60	4.30	
W	freq.	11.00	0.80	0.05	0.00	1.70	2.30	1.70	4.00	5.00	3.00	3.00	1.20	1.70	3.00	12.00	20.7	27.40
	speed	2.50	2.00	2.20	1.10	1.20	1.90	1.90	1.90	2.00	2.00	1.40	1.20	2.00	2.00	2.90	3.00	
annual	freq.	11.90	2.00	1.00	1.00	4.60	5.00	5.70	4.20	4.90	3.80	4.50	1.80	2.00	2.20	9.60	14.70	21.30
	speed	3.50	2.60	2.20	2.90	2.40	2.70	2.90	2.90	2.90	2.70	2.60	3.90	3.20	3.40	3.40	3.50	

Routine monitoring data

- Work places
- Environment
  - Water
  - Aerosol (dust)
  - Solid matterials
  - $^{222}Rn/^{220}Rn$

4. Possible scenarios for modelling

Case1 Point sources

Large quantity of ash releases from stacks

Refining

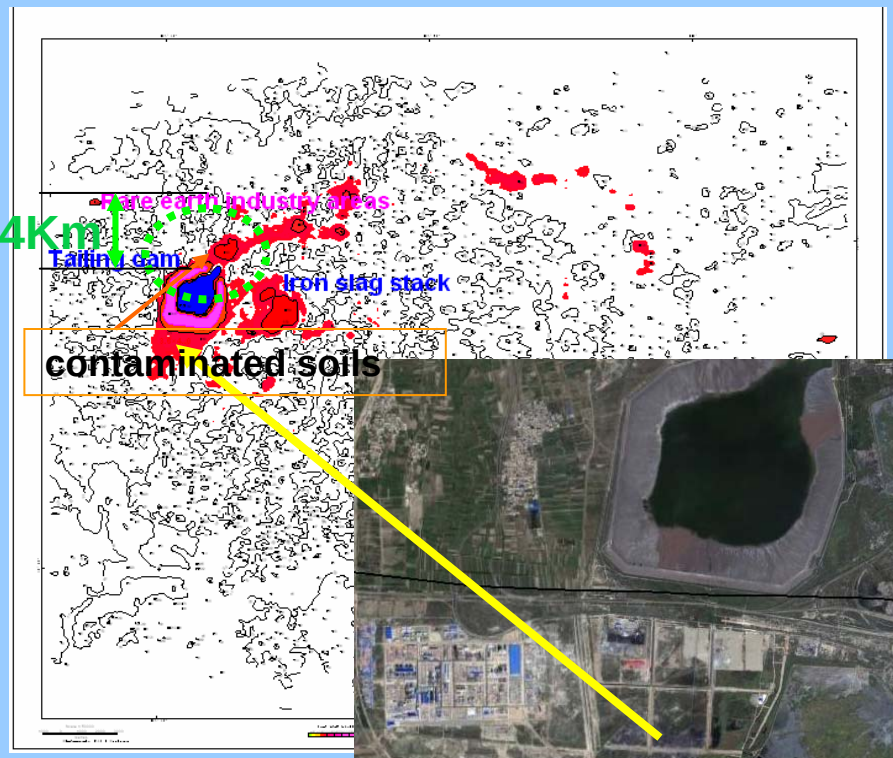
iron and steel

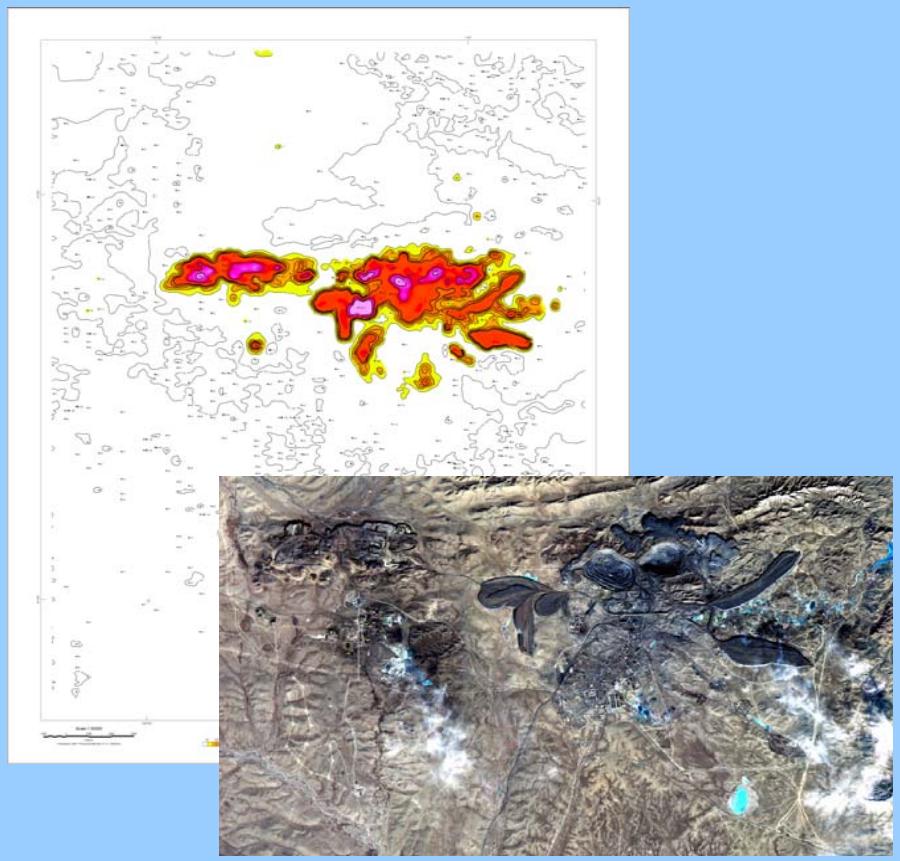
RE Processing

4. Possible scenarios for modelling

Case2 Area sources

Contaminated areas(onsite/offsite)





Case3 indoor Rn

Some other cases:
about

- **Coal industries**
- **Phosphate industries**

Which code(s) should be used?

Models used

Scenario	Detailed Model	Screening Model
Point source	PC-CREAM	CROM COMPLY
Area source	RESRAD-OFFSITE DOSDIM (+ HYDRUS) AMBER	PRESTO
Area source plus river	RESRAD-OFFSITE (AMBER)	

After the material of Second Working Group Meeting**, 2009.9.23**

Models available within group

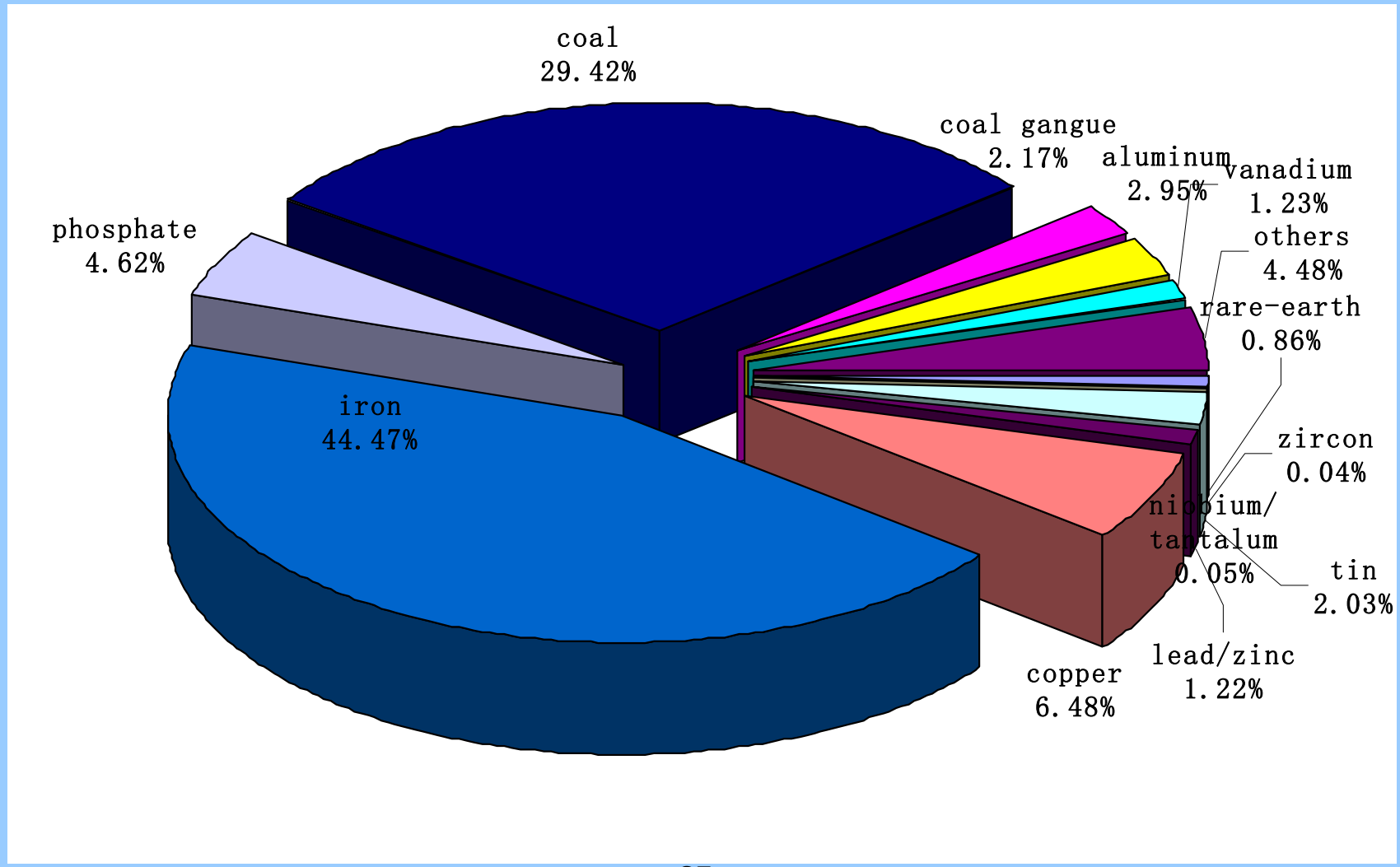
- **CROM**
- **PC-CREAM**
- **RESRAD-OFFSITE**
- **PRESTO**
- **COMPLY**
- **(Radon code) exhalation into buildings**

After the material of Second Working Group Meeting**, 2009.9.23**

CROM – Juan Carlos
RESRAD – Charley, Dr. Sunita Kamboj
ERICA Tool – Justin
ReCLAIM – Kremena

2011 programmes

NORM solid waste distribution in China



2011 new programmes

- **Coal industries**
- **Phosphate industries**