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A case study of occupational doses in NORM industries in China

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Contents

1. Introduction

NORM Sources in China

11 mining and resources :

- **rare earth elements ,**
- **niobium/ tantalum,**
- **zircon and its oxides,**
- **tin,**
- **lead /zinc,**
- **copper,**
- **aluminum,**
- **vanadium,**
- **iron and steel,**
- **phosphate,**
- **coal.**

Uranium / Thorium mining and milling…

IAEA No.49

(1) Extraction of rare earth elements;
(2) Production and use of thorium and its compounds;
(3) Production of niobium and ferro-niobium;
(4) Mining of ores other than uranium ore;
(5) Production of oil and gas;
(6) Manufacture of titanium dioxide pigments;
(7) The phosphate and potash industries;
(8) The zircon and zirconia industries;
(9) Production of tin, copper, aluminum, zinc, lead, and iron and steel;
(10) Combustion of coal;
(11) Water treatment.

The average concentration of nature radionuclides in ores and raw materials

Element / mineral in ores or raw materials	U	Ra	Th	γdose rate
	Bq/kg	Bq/kg	Bq/kg	nGy/h
REES	3972	2529	5782	2578
Nb/Ta	4,476	18131	2015	3,263
zircon	1,289	3510	1733	1,592
tin	218	540	133	272
lead /zinc	649	465	69	173
copper	142	163	34	170
iron and steel	270	288	68	162
phosphate	396	404	26	273
coal	383	212	51	153
coal gangue	171	118	82	135
aluminum	482	289	240	323
vanadium	1036	908	1501	280
others	503	744	508	422

The average concentration of nature radionuclides in solid waste

Element / mineral Waste generated	U	Ra	Th	γdose rate
	Bq/kg	Bq/kg	Bq/kg	nGy/h
REES	2081	1240	4876.3	3308
Nb/Ta	7725	7212	4191	1624
zircon	1026	945	327	358
tin	922	1377	802	601
lead /zinc	118	195	38.4	130
copper	142	155	36	153
iron and steel	246	247	135	189
phosphate	123	191	35.3	144
coal	225	326	91	162
coal gangue	191	79	92	115
aluminum	402	282	349	300
vanadium	813	675	73	264
others	338	435	119	200

Rare Earths in China

	Geological Reserves (10^6t)	Industry Reserves (10^6t)
Baiyunebo	106.0	43.5
Southen China	8.4	1.5
Sichuan Province	2.4	1.5
Shandong Province	12.70	4.00
Others	2.20	1.50
Total	127.70	52.00

Radiation levels in working sites

(nGy/h）

Places	* Shandong Province	* Guangdong Province	Inner Mongolia, Baiyunebo
Plant ambience		48. 3~65. 1	60 - 100
workshop	152.1~299.6		146 -220
Tailings	115.4~25.4.9	2810~3200	400-800
Raw materials	320.4	771~1022	2500-3000
Mining site	272.4~816.9		600-2000

*after Chen Zhidong,2004

2. A case study in the Inner Mongolia, China

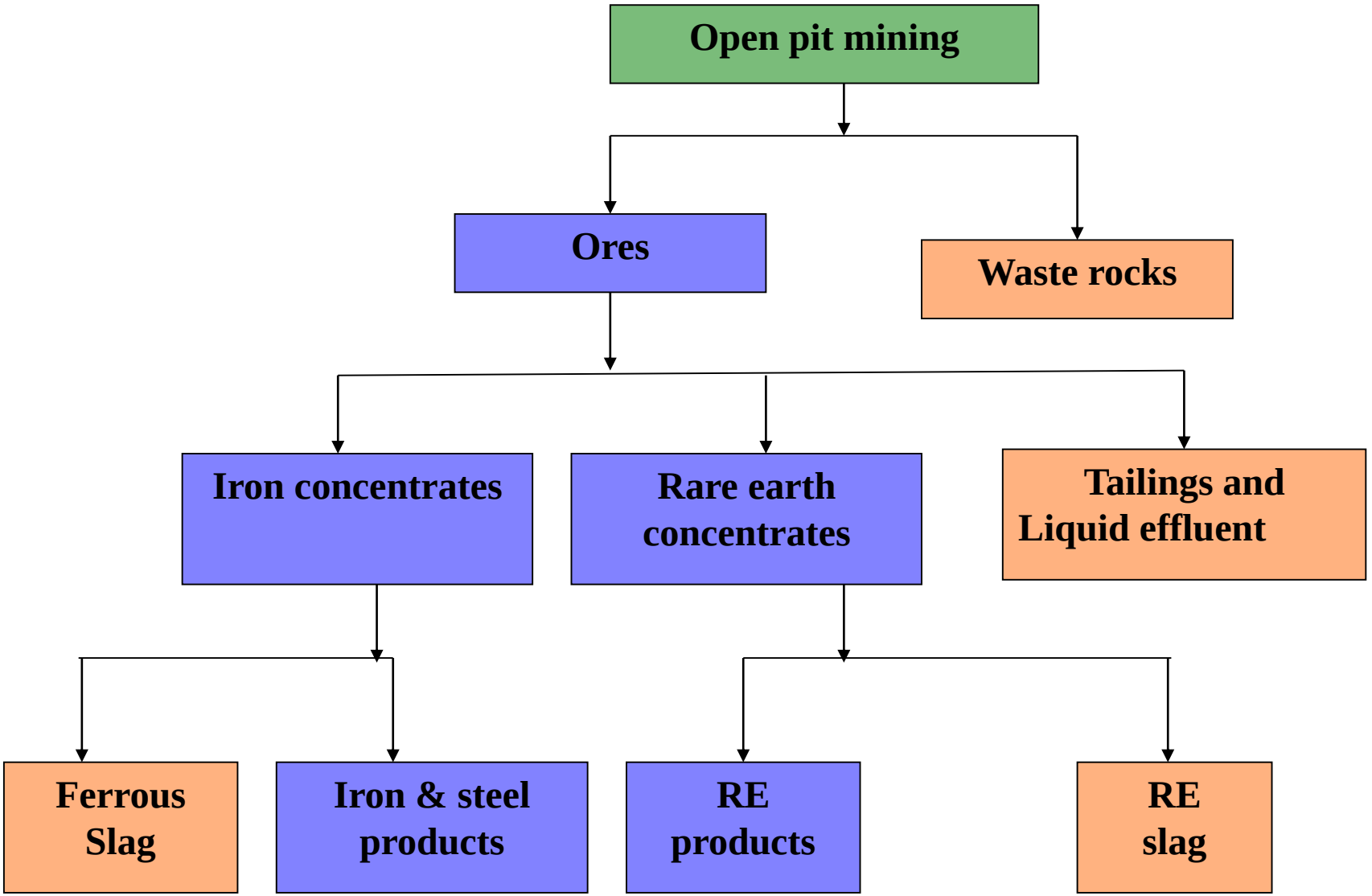
Rare earth mines have been discovered widely in China, the mines in Baiyunebo are the largest in China.

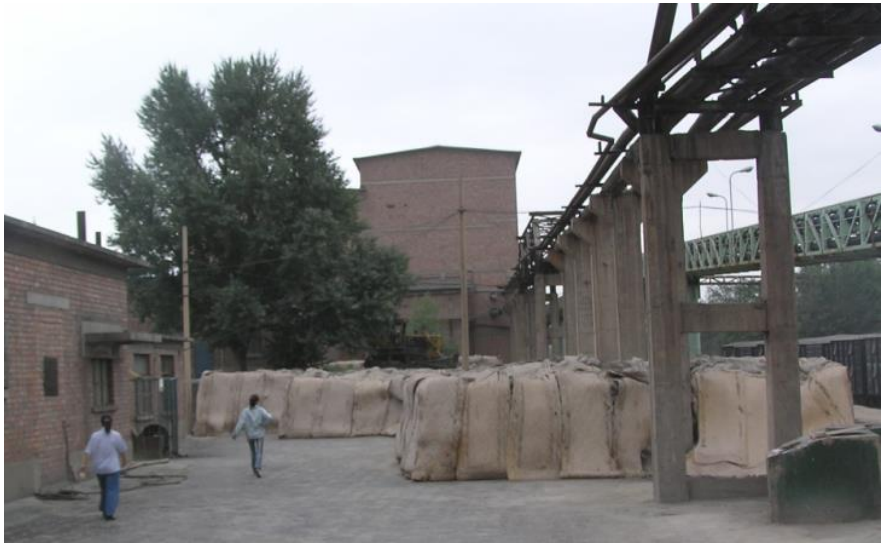
Baiyunebo mines are characteristic of iron, rare earths and niobium. The mines extend about 18 km east-westward, and 2 to 3 km south-northward. Rare earth minerals contain high radioactivity, as a result, radiological impact on the workers, as well as the public.

Mining and transportation

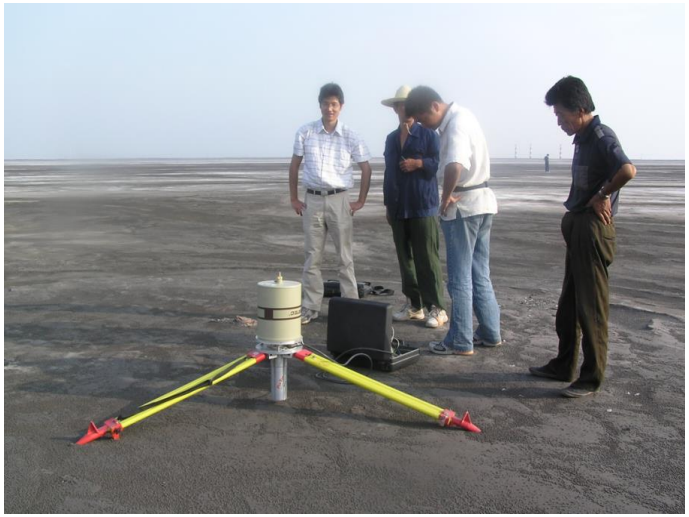
Waste rock dumps

Major flow chart of rare earth and Iron & steel production





rare earth concentrates



tailing pond

rare earth slag

ferrous slag

Radiation levels in working places

Background radiation level :85nGy/h.

The typical radiation levels(about 55Km^2) : 200 - 800nGy/h

Mining sites: 600 to 2000nGy/h, *175Bq/m^3 (^{220}Rn)

Waste rock dumping sites : 400 to 800nGy/h

in some waste rock areas, up to1200 nGy/h

Tailing pond:600～1100nGy/h

Ferrous slag dump:500～2800nGy/h

RE slag:>1500nGy/h

*Crashing and milling Workshop: 146 -220 nGy/h,

167-287Bq/m^3 (^{220}Rn)

Rare earth concentrate storage:2500-3500nGy/h

**After Liu yanyang, 2010; Robert K. Smith, 2012;Zhao Ruyi,2006;Wang LInxiu,2001*

Radioactivity Assessment in Baiyunebo

For workers(2000h/a) receive additional exposure

The general workers in the typical radiation levels

about 0.24 mSv/a (gamma)

Miners and trucking workers: > 1.0 mSv/a (gamma)

workers in the dumping sites: about 0.7mSv/a (gamma) and 2.38mSv/a (^{220}Rn).

3. Discussion and conclusion

Challenges:

1mSv/a ???

1 Bq/g for raw materials

1kBq/m^3 or 2.7kBq/m^3 or 3.7kBq/m3 radon concentration for underground mining

Dose rate (KUTh) (nGy/h) =
13.08×K(Bq/kg)/313+5.674×U(Bq/kg)/12.35+2.495×Th(Bq/kg)/4.06

K		U		Th		Concerning industries
Bq/kg	nGy/h	Bq/kg	nGy/h	Bq/kg	nGy/h	
500	20.9	100	45.9	100	61.5	Metal and nonmetal
800	33.4	200	91.9	200	122.9	
1000	41.8	500	229.7	500	307.3	
2000	83.6	1000	459.4	1000	614.5	**REES ,Nb/Ta,zircon**
		2000	918.9	2000	1229.1	
		5000	2297.2	5000	3072.7	

Radon concentration in different sites

Radon (Bq m^{-3})	sites
50	Open pit mining sites Most of coal mining Crashing or milling plants
100	
500	
1000	Underground mining (except coal mining)
2700	
3700	

3. Discussion and conclusion

Estimation of external exposure from gamma ray

gamma ray (nGy/h)	Working time(h)	Annually averaged effective dose(mSv)
50	2,000	0.07
100	2,000	0.14
500	2,000	0.70
1000	2,000	1.40
1500	2,000	2.10
3000	2,000	4.2

3. Discussion and conclusion

Estimation of radiation exposure from radon and its progeny

^{222}Rn ($Bq\ m^{-3}$)	^{222}Rn EEC(Bqm^{-3})	Working time(h)	Annually averaged effective dose(mSv)
50	17.5	2,000	0.28
100	35	2,000	0.56
500	175	2,000	2.8
1000	350	2,000	5.6
2700	945	2000	15.1
3700	1295	2000	20.7

3. Discussion and conclusion

Main contribution of o**ccupational doses in NORM industries is**

- **External dose (gamma ray) from raw material processing industries**

- **Internal dose (Radon) from mining / underground mining**

Thank you for your attention!