The second EAN $_{NORM}$ Workoshop, Dresden November 24-26, 2009

NORM in the proces of energy generation – from a mine to a power plant

the opportunity of a effective and coherent treatment of NORM type waste

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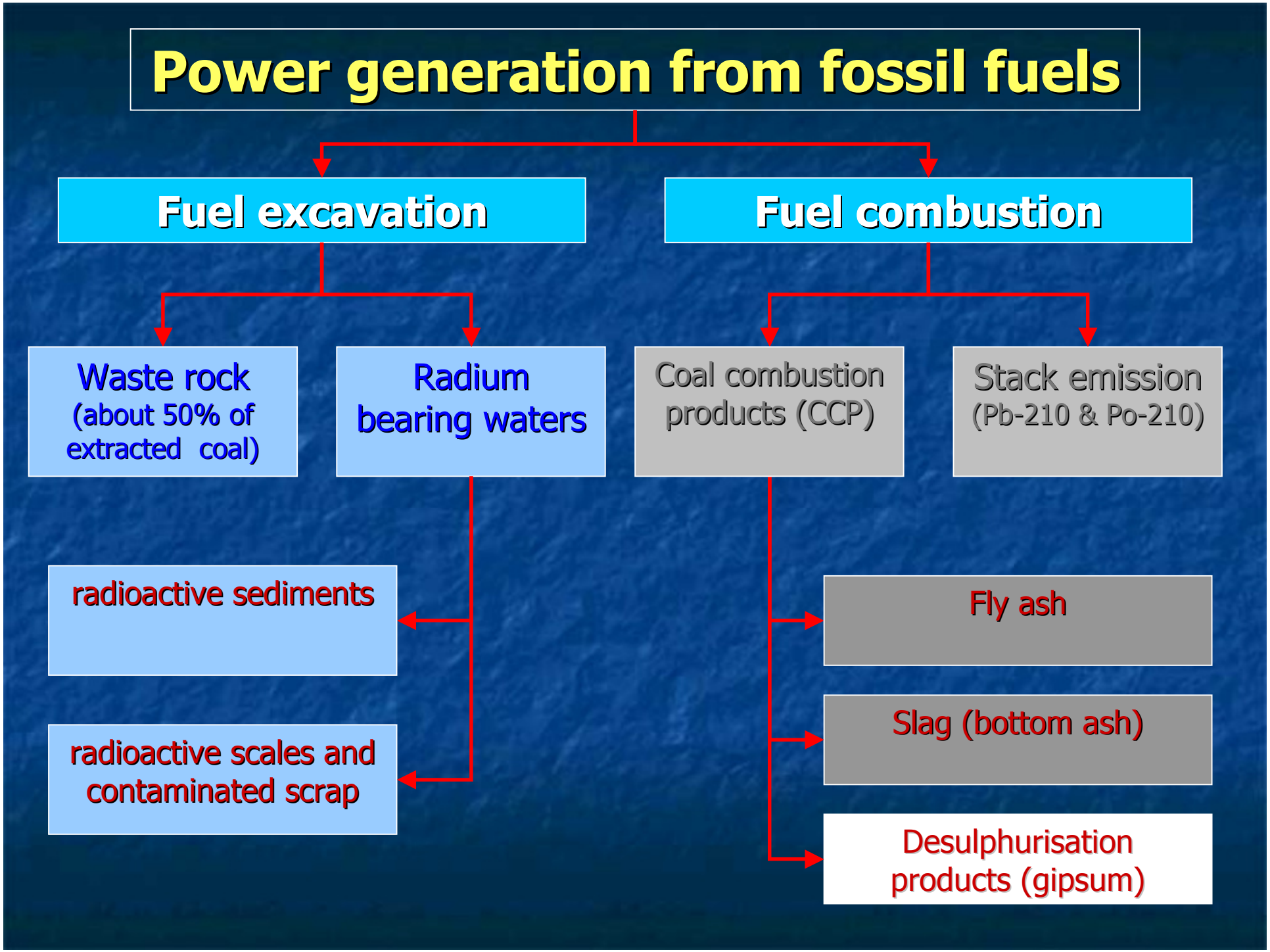
GIG


Power generation from fossil fuels
Fuel excavation
Fuel combustion
Waste rock
(about 50% of extracted coal)
Radium bearing waters
Coal combustion products (CCP)
Stack emission
(Pb-210 & Po-210)
radioactive sediments
radioactive scales and contaminated scrap
Fly ash
Slag (bottom ash)
Desulphurisation products (gipsum)

Shaft mine & longwall mining

comprises three basic equipment components:

- movable roof supports,
- a coal extraction machine that moves back and forth across the coal face, (shearers or ploughs)
- an armored conveyor at the coal face.

- As the coal is removed and the face advances, a system of controls and hydraulic cylinders snake both the roof supports and the conveyor forward.
- The roof of the mined out section is allowed to collapse behind the shields, forming gob, generally causing some **surface subsidence**.

Mining Waste

waste rock

created during shafts sinking and driving underground galleries. This category consist of all kinds of carboniferous rocks

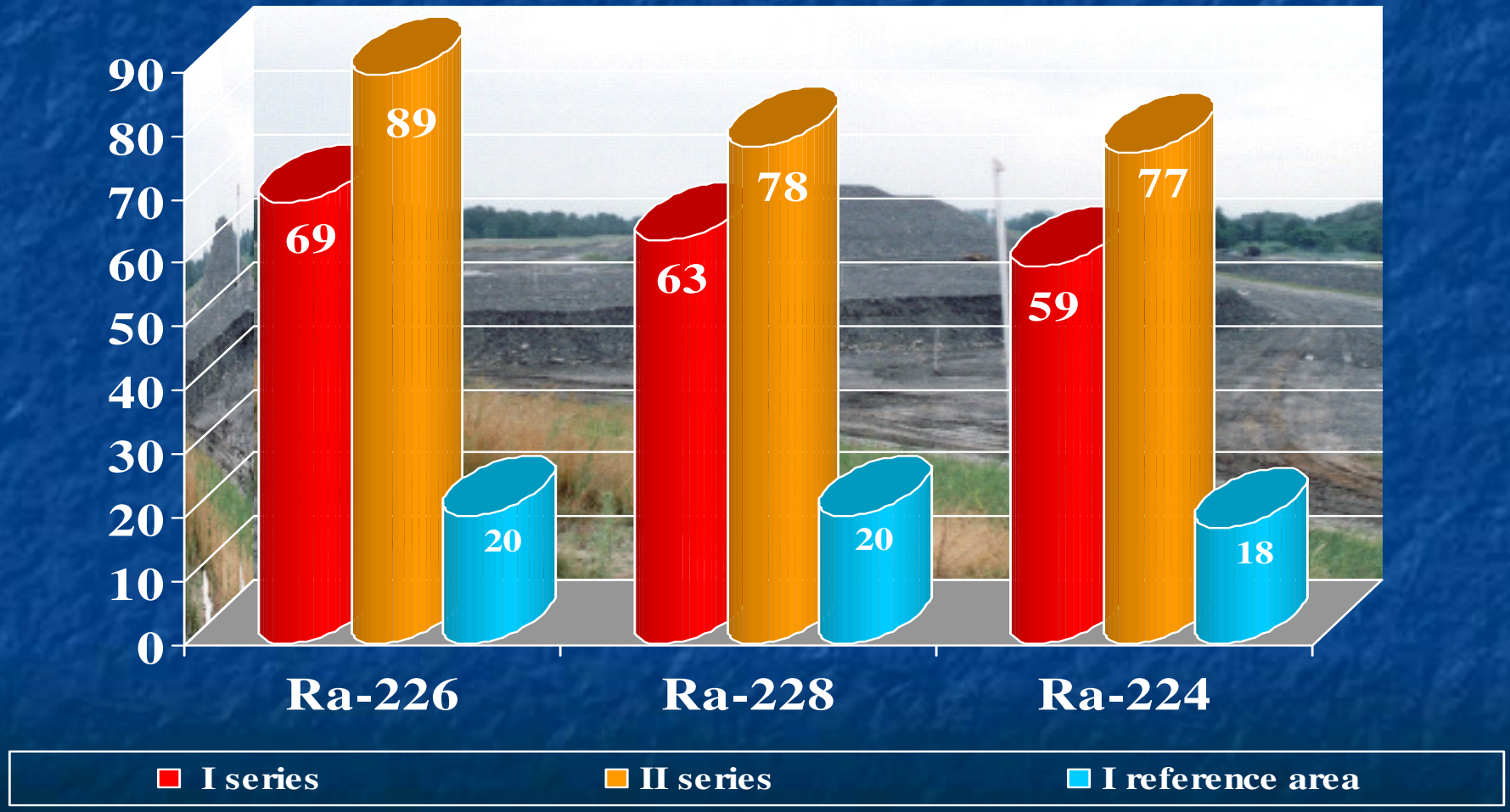
Total yearly amount of mining waste is about 40 millions tons

tailings from coal cleaning (gangue)

created during coal wet or dry cleaning, jigging, sink-float. Mainly carboniferous argillaceous rocks originating from floor or roof and interlayer.

Activity concetration of radium in waste rocks against common soil

[Bq/kg]



The derived effective dose

The biggest difference between air kerma rate on the waste rocks dump and the reference area was:

$$\Delta\dot{K} = 76 \quad \text{nGy/h}$$

Assumtions :

- **time of exposure 365×24 [h]**
- **adult person**
- **ROT (rotational geometry)**
- **average energy 600 keV**

/according to ICRU Report nr 57/

E = 0.542 mSv

That constitute about 20% of medium dose from natural gamma background on territory of POLAND

Radium-bearing waters

- All coal mines have to pump water out of the underground galleries
- In 40 out of 50 coal mines in Upper Silesia brines with high concentration of radium occur (daily surface discharge of saline water is about 100 000 m^3)
- Some proportion of radium remains in underground galleries due to spontaneous precipitation or technical measures but up to 40% of the total inflow is pumped onto surface

Radium-bearing waters

type of water	^{226}Ra *[kBq/m^3]*	^{228}Ra *[kBq/m^3]*	Ba^{2+} *[g/l]*	SO_4^{2-} *[g/l]*
A	0.5 - 390	0.3 - 150	**Up to 1.5**	traces
B	0.1 - 20	0.1 -40	**no**	Up to 15

Behaviour of radium depends mainly on the presence of barium ions in water

Radium in sediments

- from waters type A radium co-precipitate with barium as sulphates, radium content in sediments and scales may **reach hundreds of kBq/kg**
- from waters type B radium is removed slowly, as a result of sorption, sediments contain up to **few kBq/kg**

SETTLING PONDS IN COAL MINING INDUSTRY

There are 25 currently working settling ponds containing sediments with enhanced concentration of radium isotopes

(the old ones are not well identified)

Total content: 5 million cubic meters of sediments

Scrap from dewatering systems of mines

Scaling of:

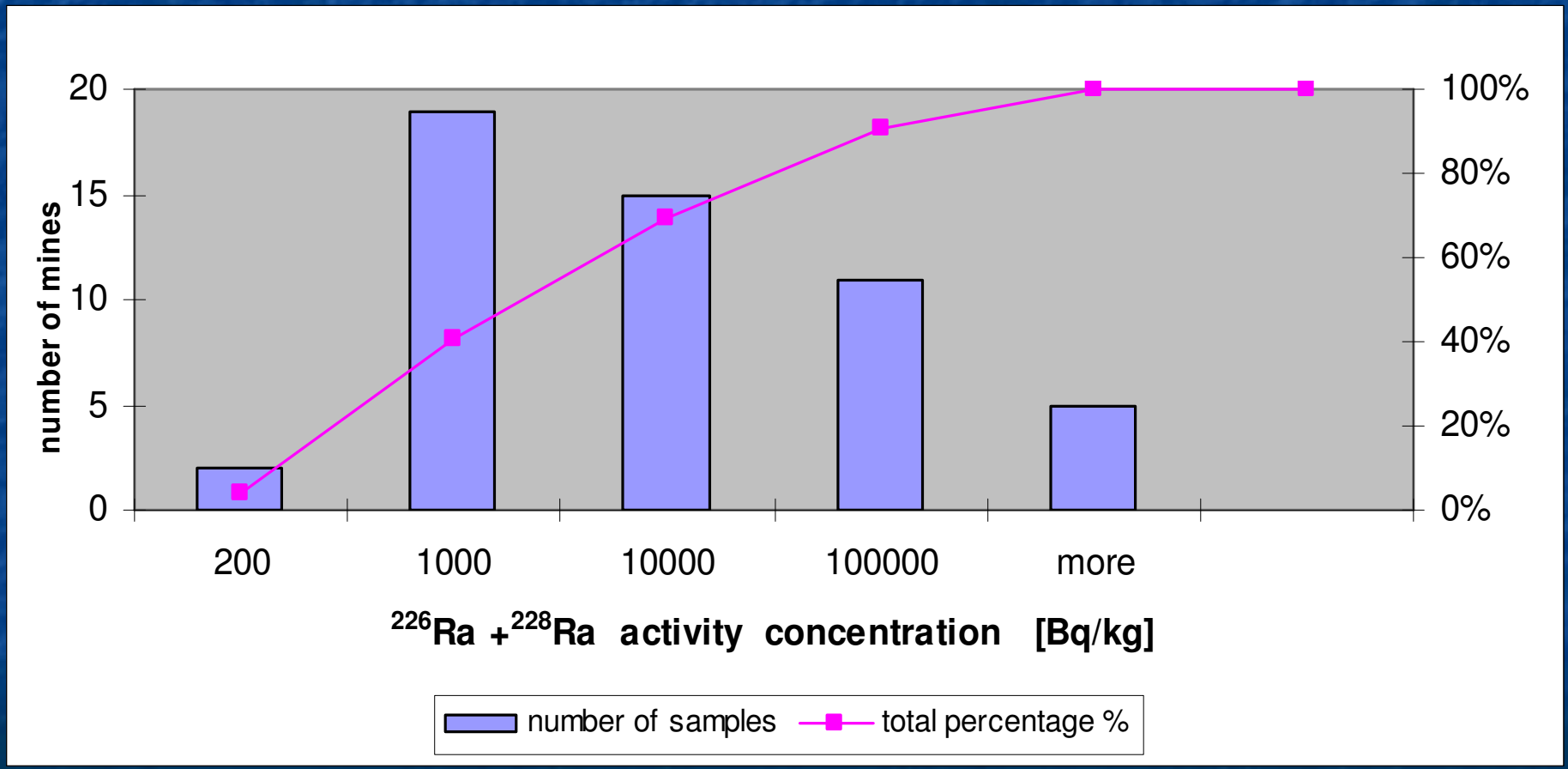
- barium sulphates from systems of formation water discharge
- calcium carbonates from systems of back-filling with ash

Shortage of:

- Appropriate regulations
- Means of decontamination

Radium in sediments in surface settling ponds and rivers

average values for each colliery



Basic statistics of sampled surface sediments

	^{226}Ra	^{228}Ra
	Bq/kg	
arithmetic average	**4 341**	**1 631**
median	**152**	**104**
minimum	**<1**	**<1**
maximum	**156 942**	**83 785**
number of samples	**711**	**711**

Coal combustion products

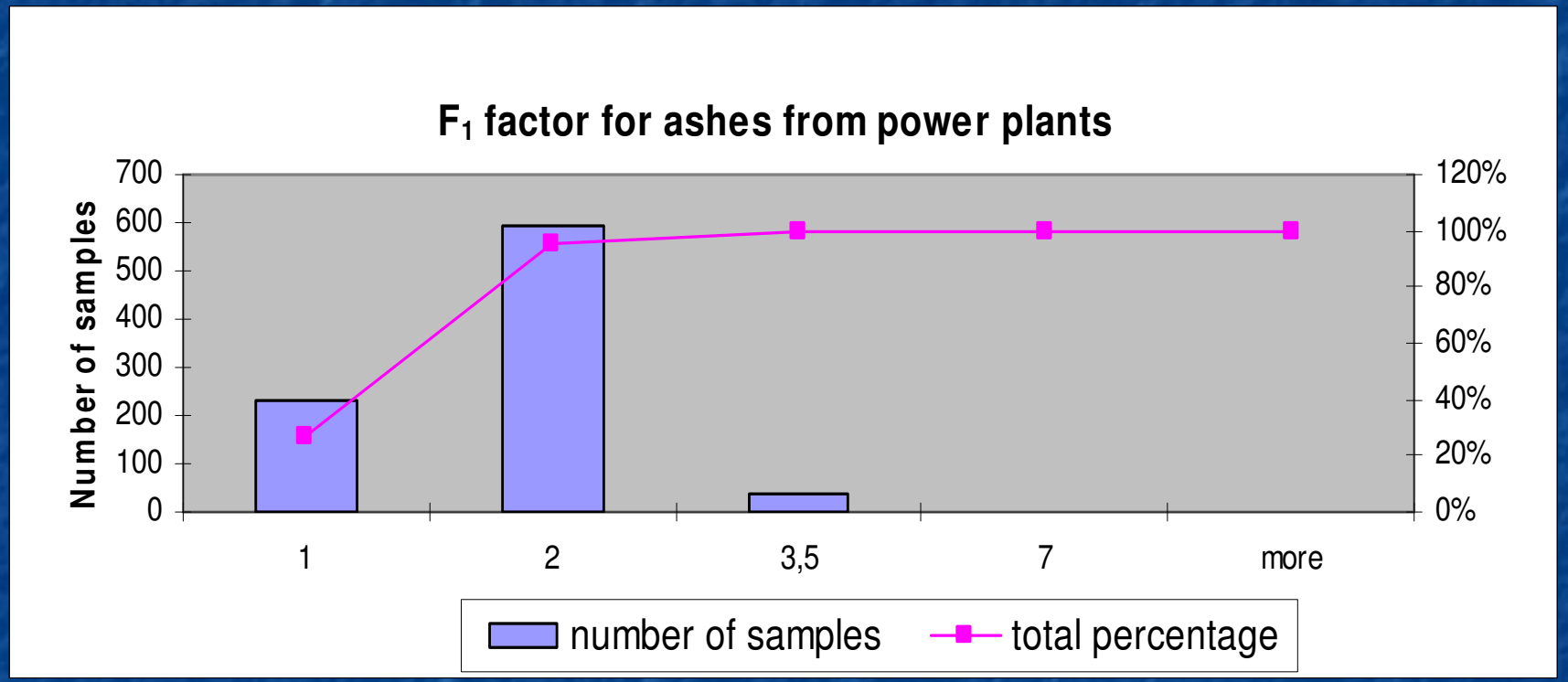
Result from high rate mass reduction process (average rate for energetic coal is 5, for good quality coal up to 20 times)

Yearly production about 15 millions tonnes

Typical measure of a CCP surface dump ca 60 ha

Widely spread through human environment (due to resuspension and application in construction industry)

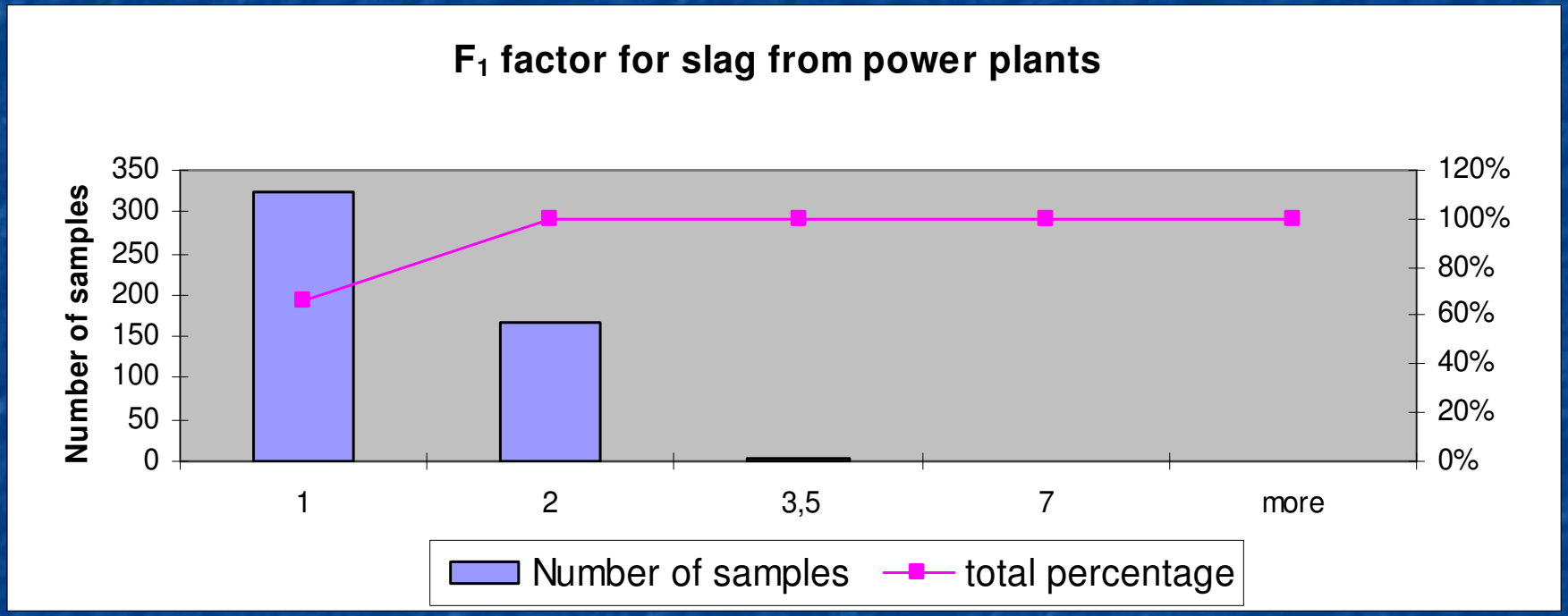
Coal combustion products



Statistic calculated based on routine measurements

F1 factor calculated according to RP 112

Coal combustion products



Statistic calculated based on routine measurements

F_1 factor calculated according to RP 112

Processes leading to the decrease of the NORM occurence

already carried out

- The use of CCP in gob fire prevention (gob sealing underground)
- The use of CCp in waste rock dump fire prevention (interlayers in coal rich waste rock on surface dump)
- The use of CCP as back-filing material (no real limits for activity concentration)

(NORM deposition or dilution by the way..)

Processes leading to the decrease of the NORM occurence

deliberately already carried out

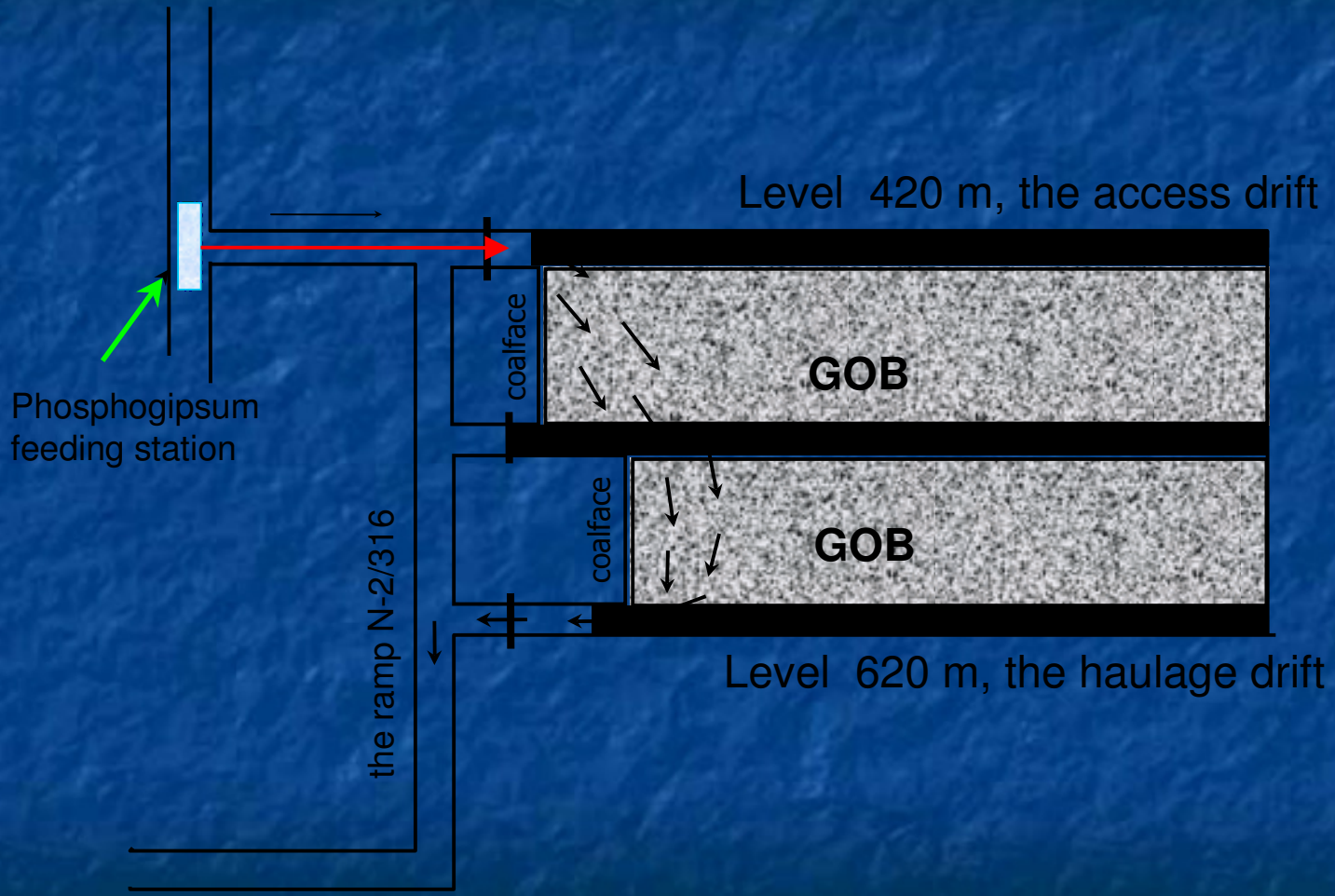
- **The use of sulpahate rich material for purification of A-type radium bearing underground waters (CCP and phosphogyspsum)**

Purification of „A” type water

water containing high enough concentration of barium ions

- **Result of natural processes:**
  mixing with other type of water containing sulphates
  forced flow through gob
- **Side effects of different technologies applying sulphate-rich materials :**
  back-filling with fly ash
  construction of dams with use of gypsum
- **Forced precipitation of radium by added phosphogypsum**

AN APPLICATION IN A MINE



Processes leading to the decrease of the NORM occurence possibilities

- The use of other NORM waste as back filing materials (i.e. red mud, black powder)
- **Dilution radium rich sediments in inert mining waste**

The balance of excavation process

year	Mine productivity (t):					
	total	coal	Waste from coal cleaning process code: 010102	Waste from flotation code: 010481	Sediment from water galleries code: 190899	Sum of inert waste: 010202 + 010481
2005	**6895262**	**3674000**	3050585	170677	1740	3221262
2006	**6760336**	**3703900**	2894547	161889	1620	3056436
2007	**7056571**	**3737600**	3163933	155038	3668	3318971

Basic statistics of radioactivity in sediments and mining waste

	code: 190899		code: 010202 & 010481	
	Ra-226	Ra-228	Ra-226	Ra-228
	Bq/kg			
average	705,6	364,4	79,7	73,1
median	409,0	246,0	73,0	79,0
Minimum	21,2	19,0	24	10
Maximum	8272,0	2880,0	189	112
Number of samples	39		15	

Radium activity concentration in mixed waste

nuclide	year	190899 + 010202 + 010481		190899 + 010102		190899 + 010481	
		maximum	*average*	*maximum*	*average*	*maximum*	*average*
Ra-226 [Bq/kg]	2005	193,36	**80,07**	193,61	**80,09**	270,57	**86,05**
	2006	193,28	**80,06**	193,52	**80,08**	269,08	**85,93**
	2007	197,92	**80,42**	198,36	**80,45**	375,81	**94,19**
Ra-228 [Bq/kg]	2005	113,49	**73,22**	113,58	**73,23**	139,93	**76,01**
	2006	113,47	**73,22**	113,55	**73,23**	139,42	**75,95**
	2007	115,06	73,39	115,21	**73,40**	175,97	**79,80**

Conclusion

In the light of different approaches to radiation risk limitation the dilution radioactive sediments with gangue and (or) waste rock originating form coal mining industry seems to be well justified from technical and economical point of view.

The balance of waste rock and gangue produced by every each mine showed that there are enough capabilities to use this technology for safe disposals of sediments had been gathered in surface settling pond due to former mining activity. However, such approach needs to be approved by appropriate regulation

Summary

- Underground coal mining creates many opportunities for safe disposal of NORM waste generated in the process as well as other ones
- An antagonistic effect can occur in case of use of different NORM waste (1+1=0)
- Chemical properties and mineral composition of mixed waste is crucial
- Appropriate regulation is necessary ….

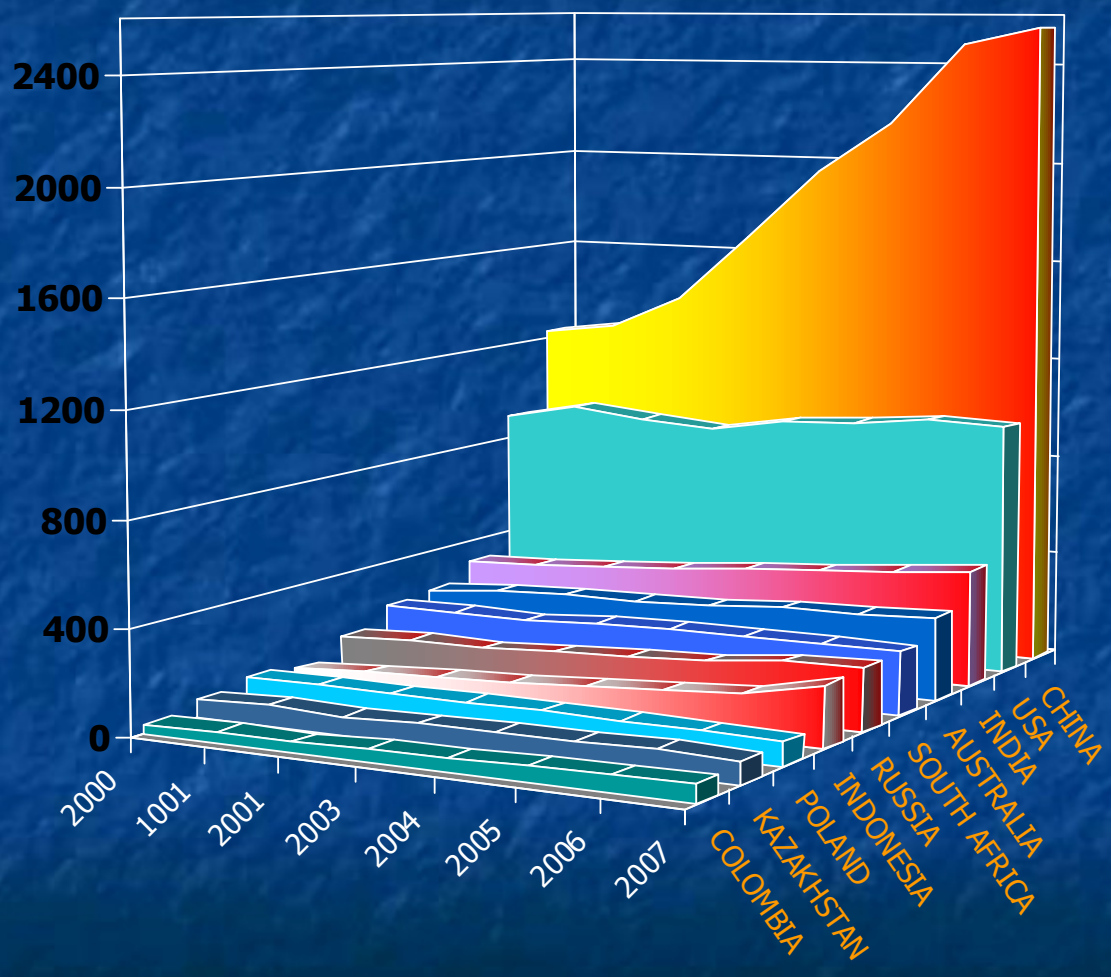
About coal mining....

This kind of industry is rarely considered as NORM industry. The example from Poland has showed something different.

In Poland (and Europe at all) coal mining is decreasing but it is worth seeing what is going on in this matter in „*emerging economies*"**.....**

World production of coal

millions metric tonnes



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Thank you for the attention !