Identification of NORMs occurrence

based on the European Waste Catalogue

Bogusław Michalik

Silesian Centre for Environmental Radioactivity

GIG

EU COMET course:

"COURSE ON NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM) IN THE ENVIRONMENT"

Natural radioactivity in environment

Natural radiation background – usually is not considered to be harmful

but .....

selective accumulation of radionuclides in some industrial processes occurs ... causing significant contamination of human environment.

NORM Naturally Occurring Radioactive Materials

TENORM Technologically Enhanced Naturally Occurring Radioactive Materials

Definitions: IAEA Safety Glossary (version 2.0):

Radioactive material

Material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity

NORM

Radioactive material (as defined above)
containing **no significant amounts of radionuclides other than naturally occurring radionuclides**

So if it's not subject to regulation, it's not NORM !

TENORM:

- Not defined in the Safety Glossary
- It does not serve any useful purpose for radiation protection
- Its use is discouraged

NORM & TENORM rationale

The term NORM should be used only for cases when a radiation hazard emerges due to the **presence of materials with elevated concentration of natural radionuclides**, significantly above the average level of radioactivity, albeit not related to or caused by any type of human activity.

It has to be pointed out that NORMs are taken into account in the radiation hazard assessment scenarios **only in cases when appearing in the natural or work environment due to industrial activity, otherwise they are treated as a component of the natural background** and not taken into considerations as enhanced radiation risk.

NORM & TENORM rationale

The acronym TENORM is used for the description of any raw material, product or waste, in which concentrations of the natural radionuclides have been **altered (enhanced) as a result of technological processes** to levels causing a significant increase of the radiation hazard above natural background. It doesn't matter if the enhancement is intentional or not.

As one can notice, in some cases NORMs are used as a substrate(s) for the processes where TENORMs are created as products, by-products or waste. On the other hand, **it's possible to create TENORMs in processes where no NORMs have been used as raw materials**.

NORM & TENORM

- Raw materials;
- Products;
- Waste and residues;

Raw materials (NORM)

- More than 400 minerals occurring in Earth crust are classified as radioactive,
- Some of them are source of valuable elements necessary in the modern economy,
- The most commonly used are:
  - Uranium containing minerals used in nuclear fuel cycle,
  - Rare Earth Oxides (REOs),
  - Phosphorite, (phosphate rock),
  - Potassium salt;
  - Thorium bearing minerals;
  - Ores of non uranium metals e.g. tin, niobium, copper, nickel.

Products

- Due their properties radioactive **elements** sometimes are used with no regards to their radioactivity:
  - Thorium in optical glass, welding rods, gas mantles;
  - Depleted uranium for shielding, ballast and ammunition
- and also some radioactive **minerals** are directly used for production:
  - Refractories and abrasive materials;
  - Glaze and ceramics;
  - Fertilisers.

NORM type waste

- Waste rocks from mining exploitation and raw materials cleaning or enrichment, together with possible contamination resulting from radionuclides leaching;
- Brines, released from oil and gas rigs or hard coal mines;
- Residues from Rare Earth Oxides (REOs) fractionation;
- Dust from of air cleaning systems;
- Residues from uranium minnig and milling (a part of nuclear fuel cycle)
- Radon and its progeny in caves, underground mines, in tunneling and in natural gas;

TENORM type waste created by mass reduction processes

- Waste from fossil fuel combustion (i.e. CCP – coal combustion products);
- Waste materials from chemical processing (mainly production of phosphoric acid and titanium dioxide pigment);
- Slag from metallurgical industry (iron ore processing and steel production);
- Waste products from non-ferrous ore processing – mainly tin, copper, zirconium and niobium;
- Tailings from rare earth metals industry.
- Deposits in underground galleries and settling ponds, scales in the dewatering systems in wells and underground mining industry;
- Solid waste from water treatment plants and geothermal energy use

(TE) NORM waste looks like …..

„common" industrial one:

- occurs in bulk quantities deposited directly in the environment,
- consists of wide variety of chemical compounds and different minerals,
- after releasing can start chemical or physical processes leading to the additional concentration of contamination,

and ….

- **contains high enough activity concentration of radionuclides to be classified as radioactive waste.**

in comparison…..

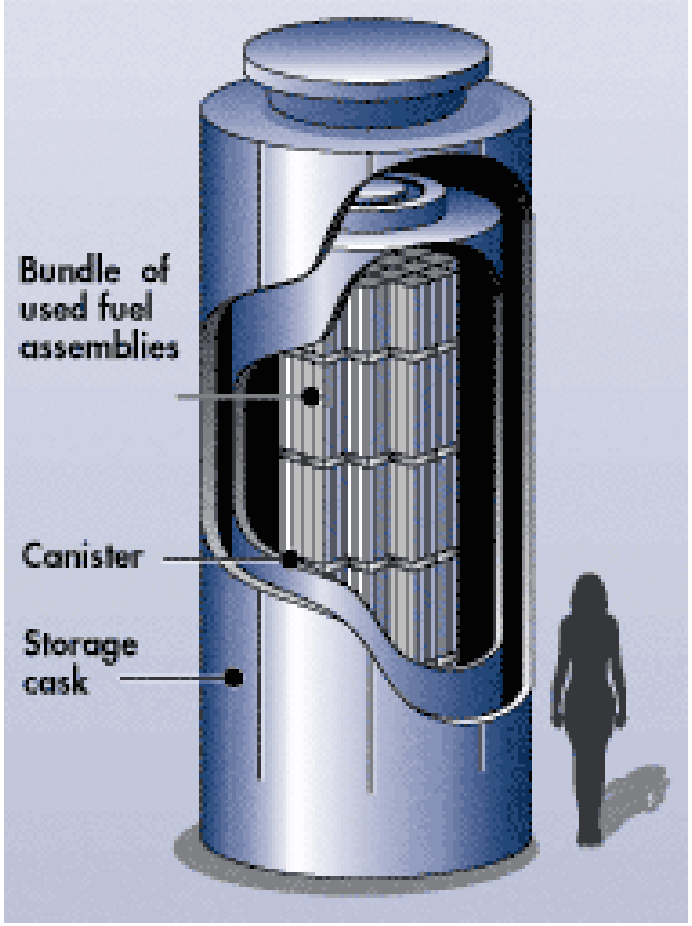
Radioactive waste characterisation

Total amount of spent nuclear fuel in USA: 58 000 tonnes.

Currently, most spent nuclear fuel is safely stored in specially designed pools at individual reactor sites……

Radioactive waste

- …or they are kept in
- **Dry Cask Storage System**



U.S. NRC – United States Nuclear Regulatory Commission

Difficulties in law enforcement….

an example…..

Jury: Energy giant must pay $2 million
By The Associated Press
Friday, March 05, 2010

A state district court jury decided Friday that Exxon Mobil Corp. failed to warn workers that offshore drilling pipes they cleaned over decades contained radioactive contamination.

Sixteen former employees of now-defunct Intracoastal Tubular Services, of Harvey, **were awarded nearly $2 million as compensation for the increased risk of developing cancer**. The jury declined to award punitive damages.

"*We still believe that our pipe did not cause any harm*," Exxon Mobil attorney Charles Gay said after the verdict.

Plaintiff attorney Tim Falcon said the former workers were disappointed by the award, but still called the finding that Exxon was at fault "a victory."

The verdict came after seven days of deliberations. No blame was placed on Intracoastal Tubular Services.

The suit was filed in 2001 after a New Orleans **jury awarded the Grefer family, which owns the property on which the pipes were cleaned, $1 billion in punitive damages against Exxon Mobil and ITCO**. The family leased 33 acres for three decades to ITCO.

A state appeals court later upheld the verdict, but reduced punitive damages to $122 million.

The European Waste Catalogue

is a fundamental part of a duly waste disposal

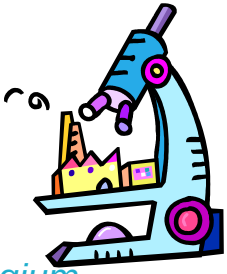
- It classifies both hazardous and non-hazardous waste produced pursuant to European Council *Directive 75/442/EEC of 15 July 1975 on waste,*
- categorizes them according to what they are and how they were produced,
- defines standardized nomenclatures

and…..

- The EWC codes are valid throughout Europe and contain just about any waste conceivable

Rules of classification

- adherence to the particular group of NORM industry according to IAEA and EC positive list, respectively; (IAEA 1-11, EC 1-14)
- occurrence in technological processes with significant initial mass reduction (mainly thermal processes) (T1)
- adherence to the kind of waste created during water (potable, technological, underground) treatment (W1)
- adherence to the kind of waste created during atmospheric air, exhausted gases or natural gas cleaning (treatment) (A1)
- data collected by (GIG 1-5)



NORM industry according to the IAEA

NORM industry	NORM industry code
Rare earths extraction	IAEA 1
Thorium extraction & use	IAEA 2
Niobium extraction	IAEA 3
Non-uranium mines	IAEA 4
Oil and gas production	IAEA 5
TiO_2 pigment production	IAEA 6
Phosphate industry	IAEA 7
Zircon & zirconia industries	IAEA 8
Metals production (Sn, Cu, Al, Fe, Zn, Pb)	IAEA 9
Burning of coal etc.	IAEA 10
Water treatment (^{222}Rn, solid residues)	IAEA 11

NORM industry according to the EC

NORM industry	NORM industry code
Extraction of rare earths from monazite	EC 1
Production of thorium compounds and manufacture of thorium containing products	EC 2
Processing of niobium/ tantalum ore	EC 3
Oil and gas production	EC 4
TiO_2 pigment production	EC 5
Thermal phosphorus production	EC 6
Zircon & zirconia industries	EC 7
Production of phosphate fertilizers	EC 8
Cement production, maintenance odfclinker ovens	EC 9
Coal fired power plants, maintenance of boilers	EC 10
Phosphoric acid production	EC 11
Primary iron production	EC 12
Tin/lead/copper smelting	EC 13
Ground water treatment	EC 14

NORM industry according to GIG

NORM industry	NORM industry code
coal mining	GIG 1
production and use of abrasive materials	GIG 2
production and use of refractories	GIG 3
processing of potassium rich minerals	GIG 4
paper production	GIG 5

Among 674 individual waste already classified in EWC 257 are at least suspected as being TENORM or NORM…..

- group 10: waste from thermal processes
- group 01: waste resulting from exploration, mining, quarrying, physical and chemical treatment of minerals
- group 06: waste from petroleum refining, natural gas purification and pyrolytic treatment of coal

an egzample: Upper Silesia Coal Basin

a post-industrial landscape affected by discharge of radium rich water discharged from coal mining industry

- Coal take-off above 200 millions of tonnes per year (in seventies of XX century) currently about 70 millions of tonnes
- 50 underground hard coal mines still in operation (in 35 administrative units)
- Daily surface discharge of water is more than 600 000 m^3

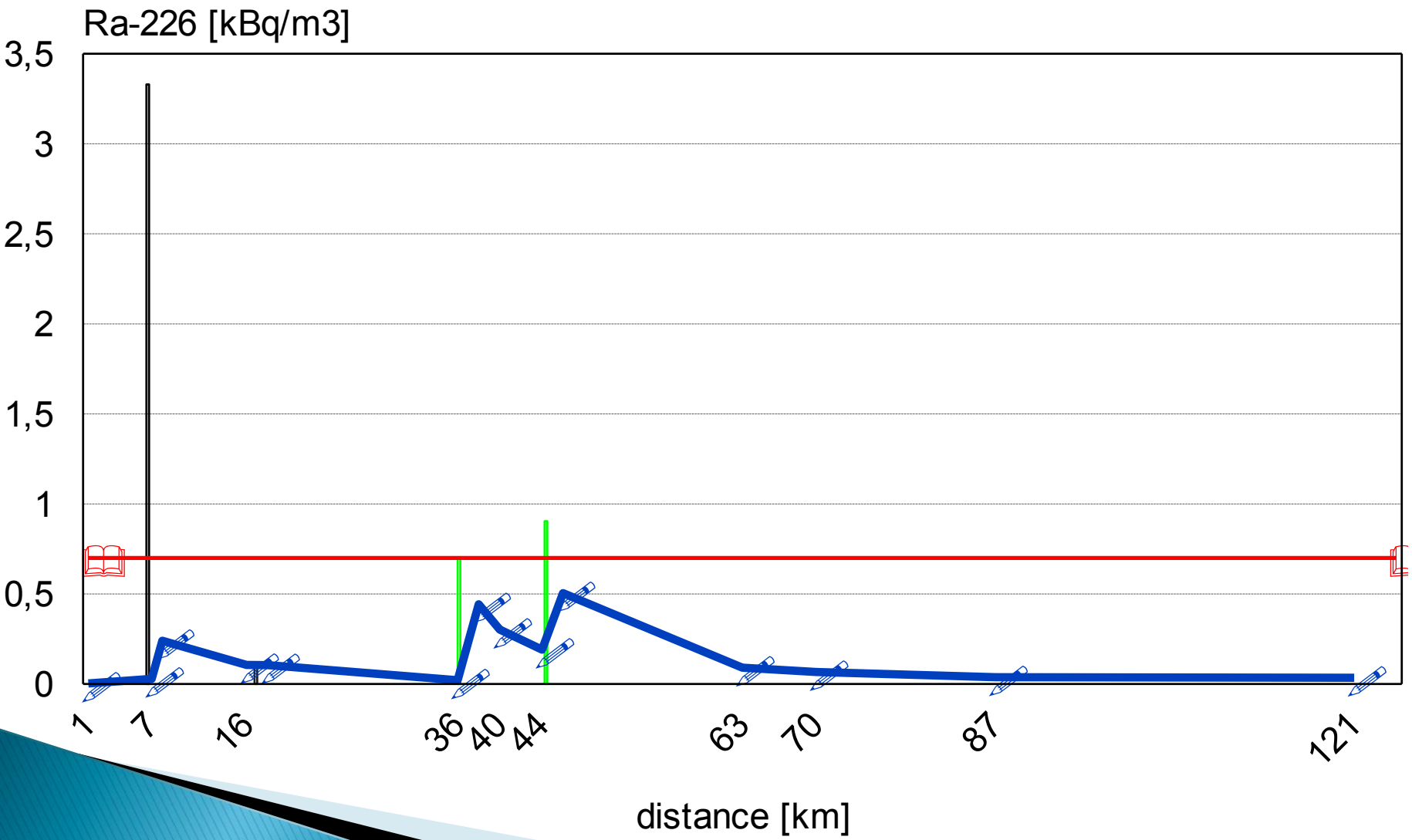
Mine waters discharged daily in to surface

CATEGORY	TOTAL OUTLOW [m^3/day]	$Cl^- + SO_4^{2-}$ [t/day]	SALT (NaCl) [t/day]
I (TDS < 1 g/dm^3)	86 322	20.7	66.1
II (TDS 1–3 g/dm^3)	190 291	127.5	288.2
III (TDS 3–70 g/dm^3)	336 987	2317.0	4291.6
IV brines (TDS > 70 g/dm^3)	**35 344**	**2321,8**	**3956.5**
TOTAL	648 944	4787.0	8602.4

Water and radium balance

mine	discharge	Activity concentration		Total Activity		salinity
		Ra-226	Ra-228	Ra-226	Ra-228	
	[m³/day]	kBq/m³	kBq/m³	[MBq/day]	[MBq/day]	[g/l]
Silesia	6000	4,06 ± 0,15	4,33 ± 0,49	23,4	24,9	35
Brzeszcze	14500	0,09 ± 0,01	0,09 ± 0,06	1,3	1,3	10
Piast						
level 500 m	11500	1,30 ± 0,27	5,96 ± 0,89	15	68,5	15
level 650 m	18000	5,62 ± 0,34	8,95 ± 0,79	101,2	161,1	60
			total	**116,2**	**229,6**	
Ziemowit						
level 500 m	11500	1,12 ± 0,09	2,00 ± 0,28	12,9	23	10
level 650 m	19000	2,58 ± 0,20	4,64 ± 0,47	49	88,2	50
			total	**61,9**	**111,2**	
			All together	**202,8**	**367**	

Radium in the Vistula river during summer



Chemical composition of waters type A and B

	unit	Type A	Type B
^{226}Ra		62,76	3,449
^{228}Ra	Bq/dm^3	34,67	5,10
conductivity	µS/cm	151 000	91 000
pH		7,25	7,53
(TDS) in 378ºK	mg/dm^3	124 300	85 300
kations			
anions			
Cl^-	mg/dm^3	77 350	50 830
SO_4^{2-}		–	2140
HCO_3^-		24,4	67,1
SiO_4^{4-}		2,00	3,45
Br-		241	155
J-		10,9	11,2
total		77 630	53 210

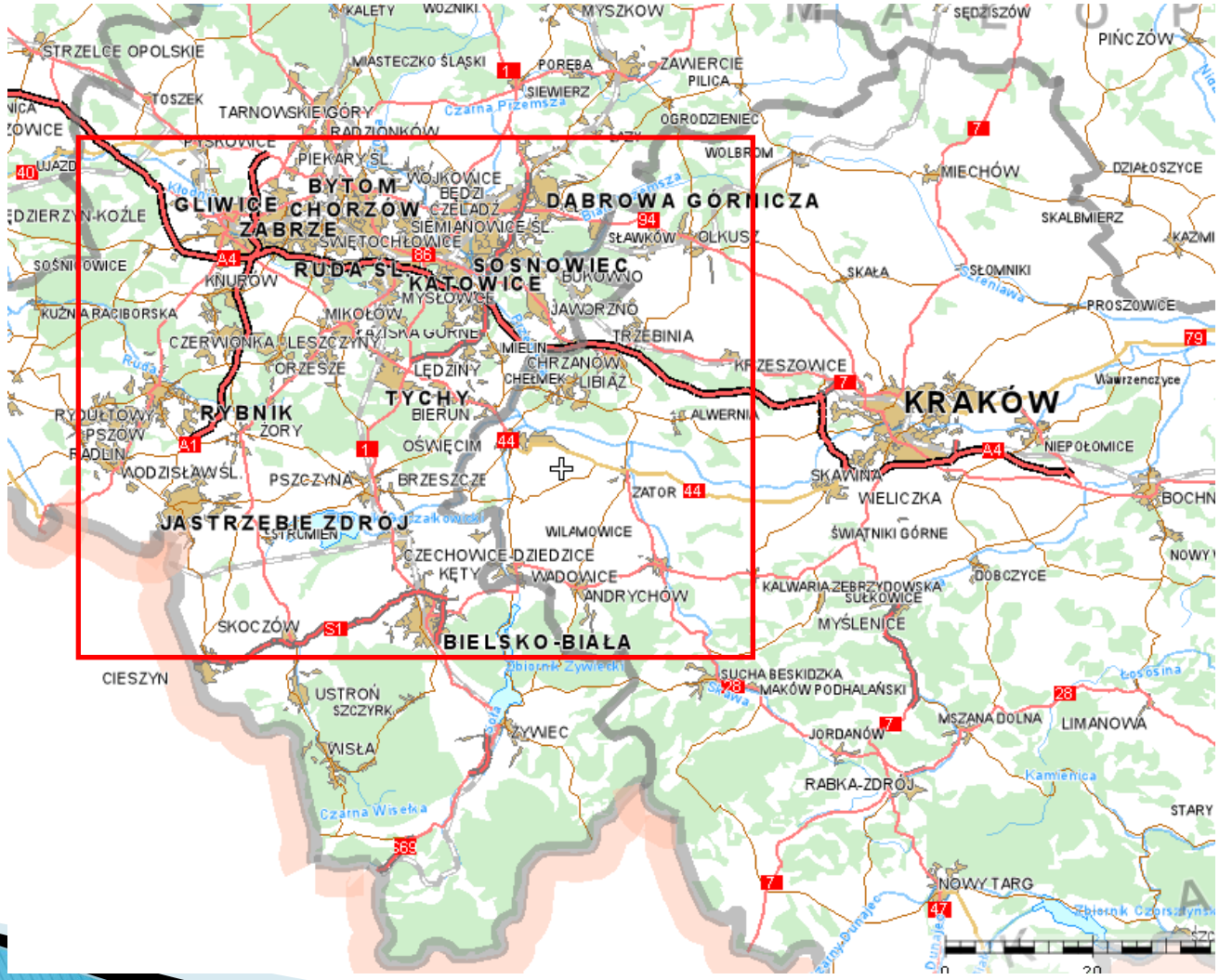
Behaviour of radium depends mainly on the presence of barium ions in water

$$Ba^{2+} + Ra^{2+} + 2\ SO_4^{2-} \rightarrow BaRa\ (SO_4)_2$$

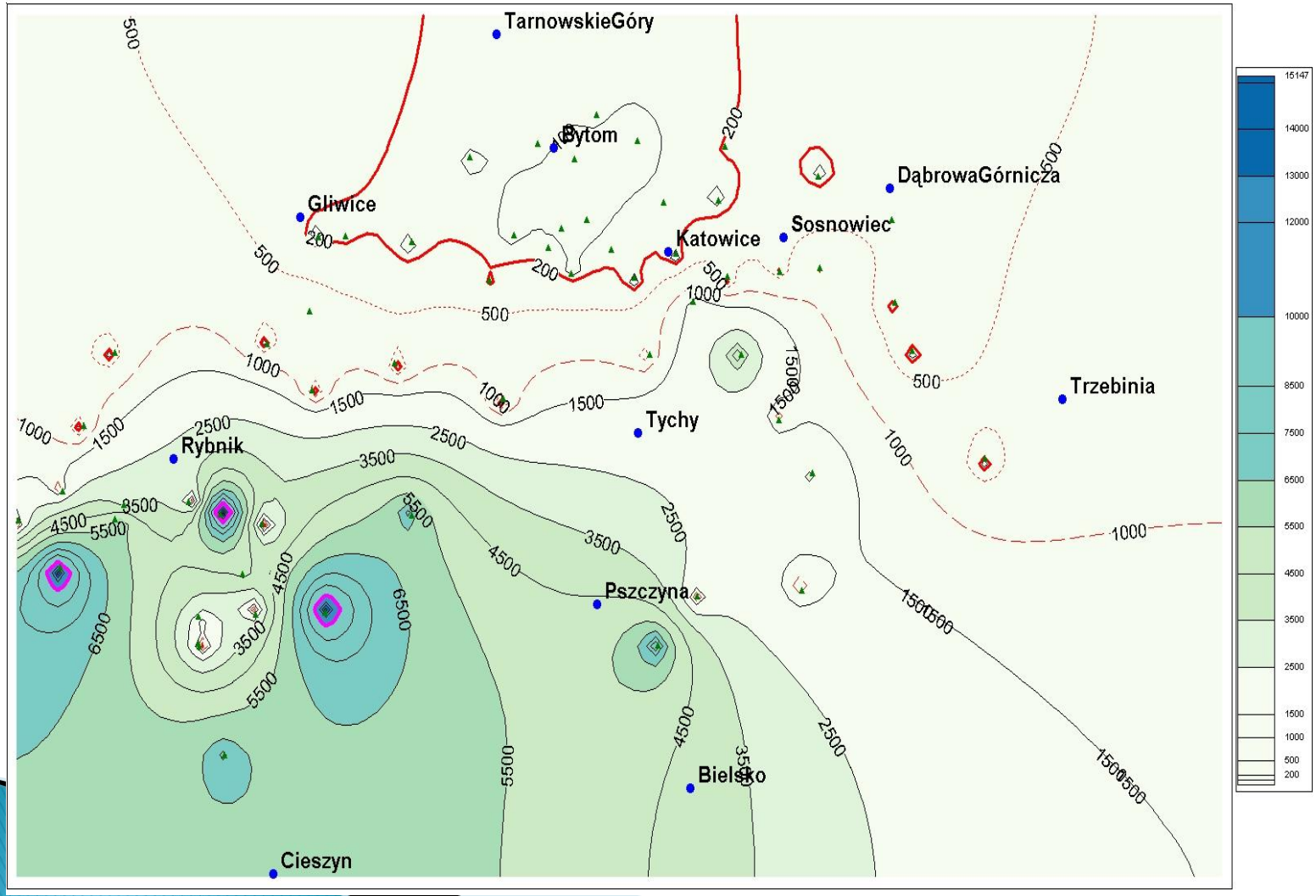
Sediments originating from mine effluents
the main source of radiation risk

- ✓Contain high enough activity concentration of radionuclides to be classified as radioactive waste,
- ✓Occur in huge quantities deposited directly in the environment,
- ✓Consist of wide variety of chemical compounds and different minerals,
- ✓After releasing can start chemical or physical processes leading to the additional radionuclides concentration,
- ✓Frequently are associated with other pollutants as heavy metals, sulphates, hydrocarbons.

Area afected by coal mining industry



The distribution of sediments with enhanced radium activity concetration



SETTLING PONDS IN COAL MINING INDUSTRY

- Artificial reservoirs, situated on territory of a colliery, sealed and protected against uncontrolled spread of sediments, periodically cleaned, access is restricted to mine staff

- Natural lakes or former fishing ponds, adapted as settling ponds without any protective layers or barriers, nowadays usually excluded from technological process, accessible for common people and non-human biota

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 cube meters of sediments

Additional legacy ….

- contaminated beds of streams, where formation water used to be discharged
- contaminated soils on neighbouring arable lands

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


Thank you for your attention