



Environmental burden of NORM residues

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Natural radioactivity in environment

Natural background - usually considered not to be harmful

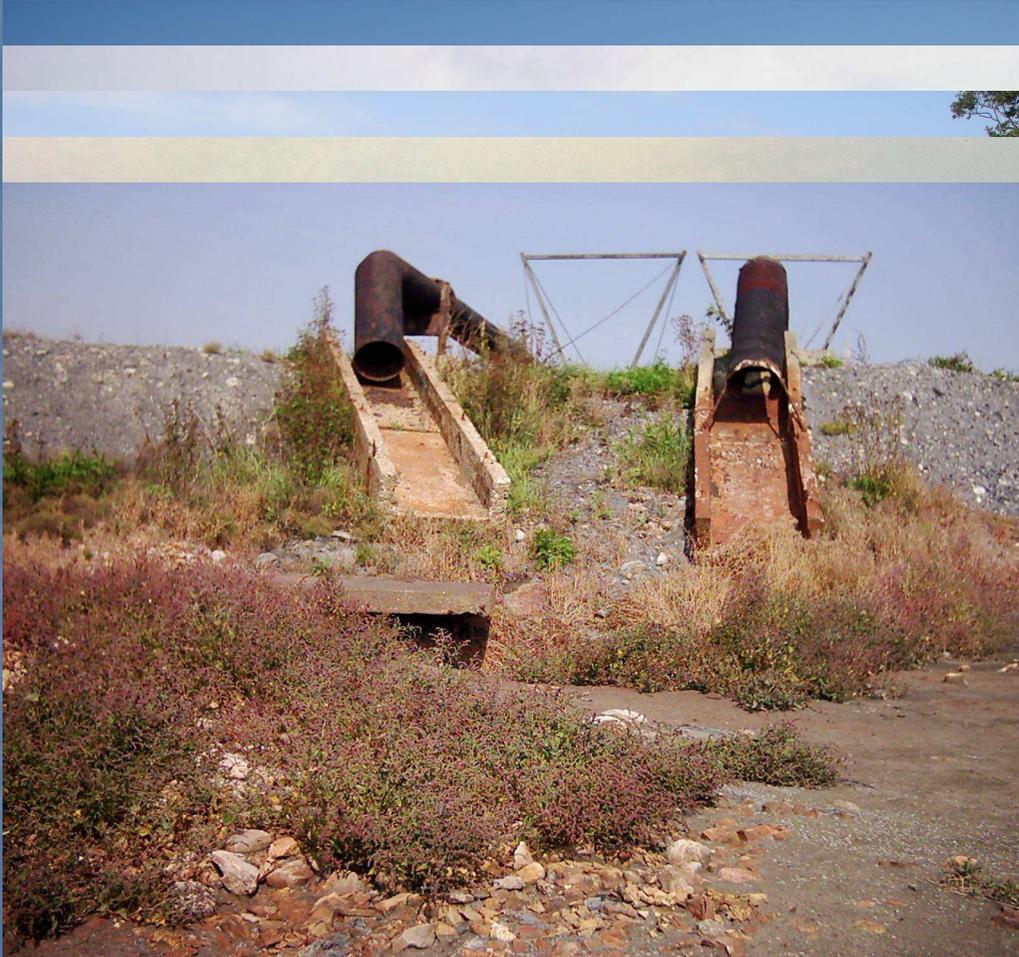
but



selective accumulation in biota occurs... causing significant contamination of human trophic chain

There are some examples of societies based on limited trophic chain where the related committed dose to individuals caused by biologically cumulated natural radionuclides as polonium and lead ingestion is significant

NORM-type waste characterisation



Contains high enough activity concentration of natural radionuclides to be classified as radioactive waste,

Occurs in huge 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 radionuclides concentration,

Frequently is associated with other pollutants as heavy metals, sulphates, hydrocarbons.

If significant bio-accumulation occurs in not altered environment could one imagine what is going to happen in the neighbourhood of a heap of NORM waste?



at the border of abiotic and biotic environment

NORM-caused environmental risk characterization



- Natural radionuclides = **long lived** radionuclides
- Almost all natural radionuclides are **alpha emitters**
- **Risk evolution**: increase of concentration of progenies - new elements = different properties (i.e. radium -> polonium)
- **Risk scenario** differs from these ones usually considered in radioecology



Radiation risk pathways

- Exposure to external *gamma* radiation
- Exposure to external *alpha* radiation
- Internal exposure (committed dose)
- Exposure to radon and radon progeny in soil gas
- Migration and accumulation in different compartment of environment
- Lack of equilibrium among parts of decay series
- Bio-accumulation

Environmental effects ????

an reductionistic approach:

- early mortality
- morbidity
- reduced reproductive success

Reflected in the concept of

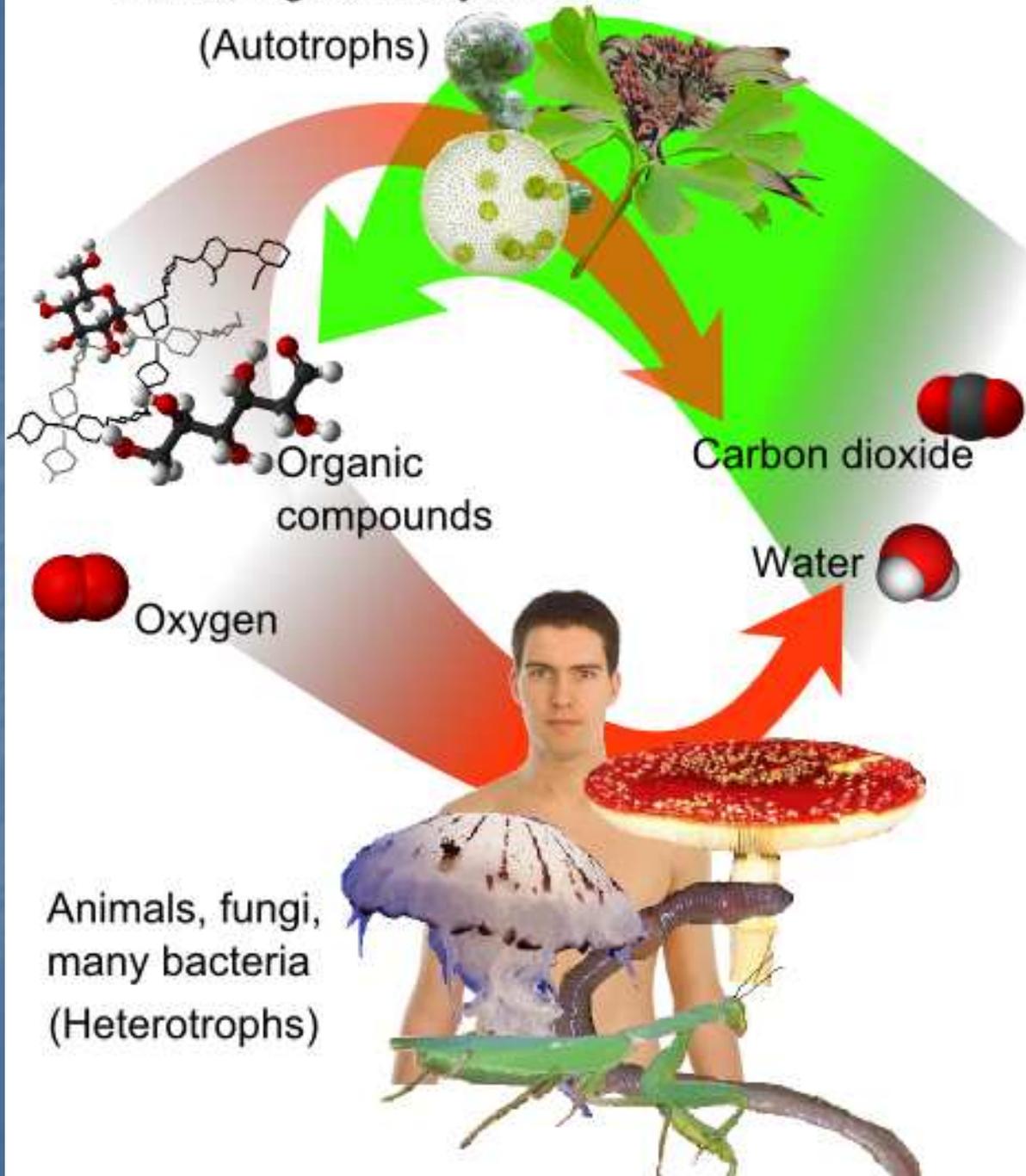
„reference organism“



ICRP PUBLICATION 103

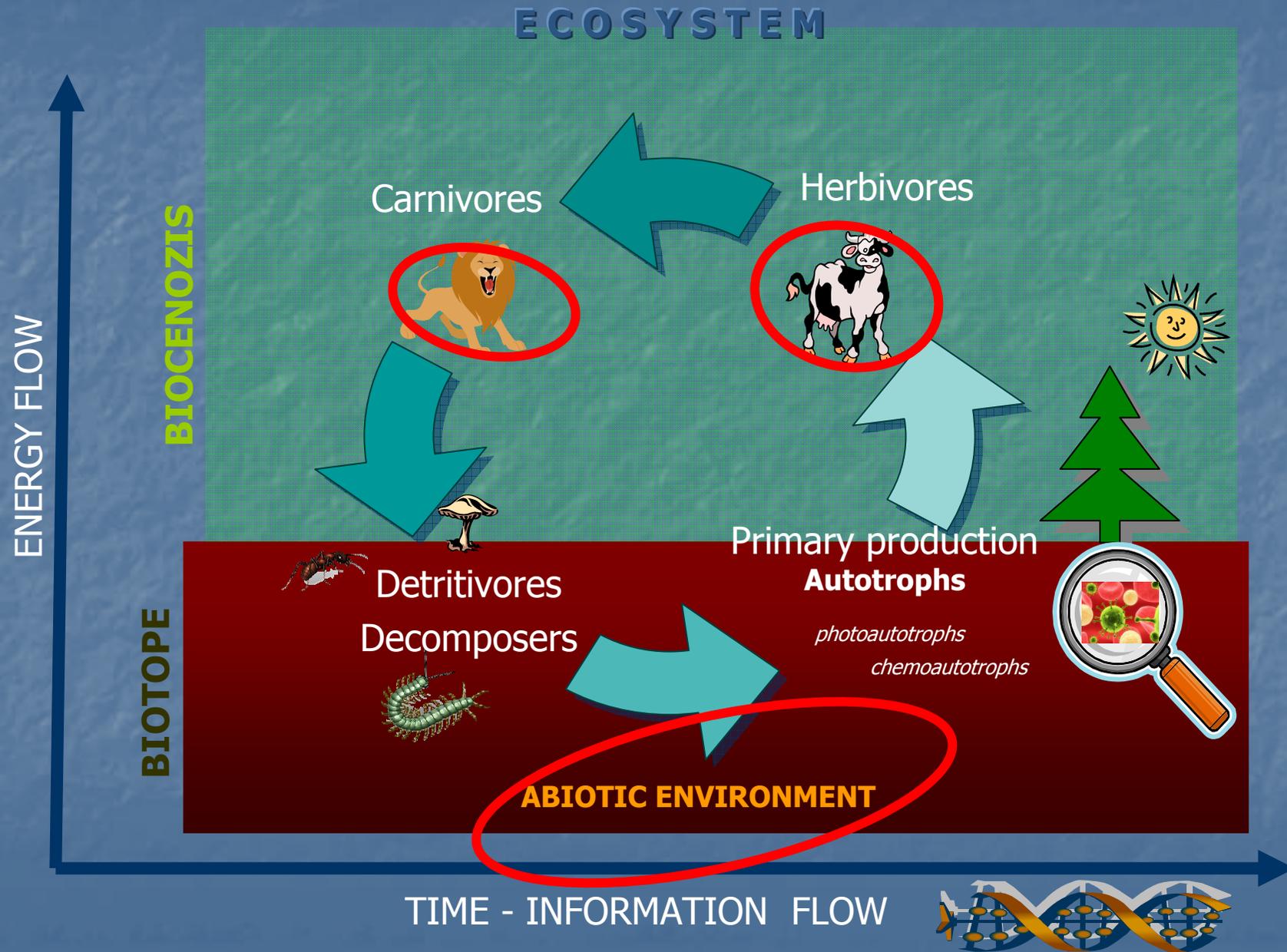
The 2007 Recommendations of the International Commission on Radiological Protection

Plants, algae, many bacteria
(Autotrophs)

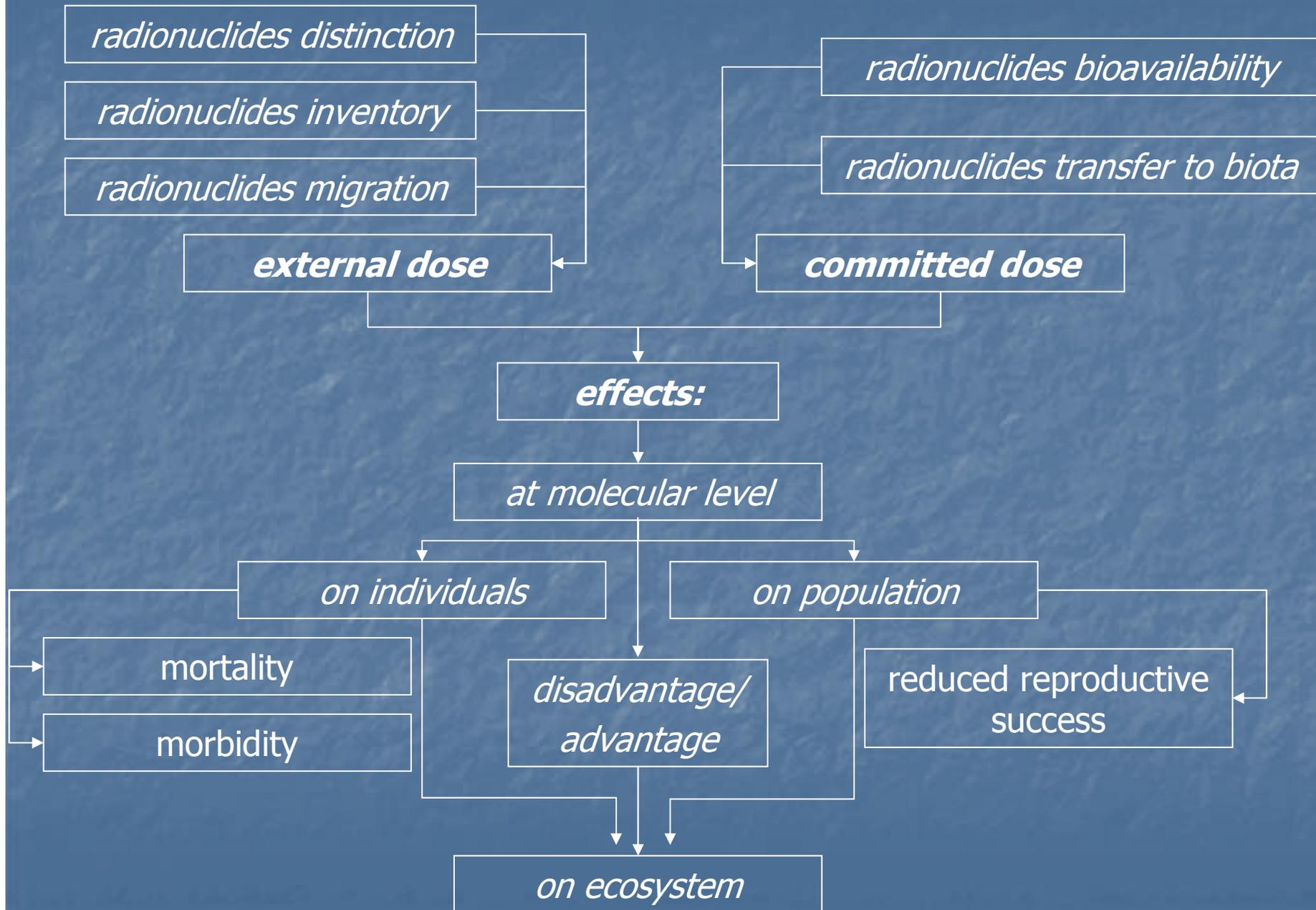


Animals, fungi,
many bacteria
(Heterotrophs)

ECOLOGY & EVOLUTION



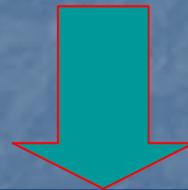
What is the expected effect on environment ?



Effects on biota

Interaction of contaminants with biota takes place at the cellular level

Cellular response is the first manifestation of harmful effects, so it is a suitable parameter for the early detection of the action of pollution



Genetic test-systems should be used for an early and reliable displaying of the alterations in ecosystems

Environmental risk assessment

looking for relationships



- Concentration of radionuclides in abiotic environment ?
- Migration of radionuclides in abiotic environment ?
- Exposure to external gamma and alpha radiation ?
- Biological availability of radionuclides ?
- Transfer factors of radionuclides' into biota and committed dose ?
- **Effects on biota**

May be it is caused by other, associated pollutants?

An example...

Effects on biota

- high level of genotoxicity has been observed in all samples tested
- only samples with the highest activity concentration showed toxicity estimated from the root proliferation

Cytotoxicity and genotoxicity of sediments sampled from Upper Silesia post-mining areas.

Sample	Total cells	MI, %	AT	AC, %	Aberrations in types				
					f1+m1	f2	m2	g	3p
R	1749	32.47 ± 2.30	4063	2.75 ± 0.25	6	6	57	31	12
B1	1809	31.18 ± 2.34	3693	2.29 ± 0.16	13	2	34	31	10
B2	1765	34.87 ± 1.31	3860	2.92 ± 0.29	2	3	57	42	12
control	1810	33.41 ± 1.58	7842	1.27 ± 0.08	16	20	15	26	14

MI – mitotic index; AT – ana-telophases scored; AC - number of aberrant cells; f1, m1 – chromatid (single) fragments and bridges; f2, m2 – chromosome (double) fragments and bridges; g – lagging chromosomes; 3p – multipolar mitoses

An example...

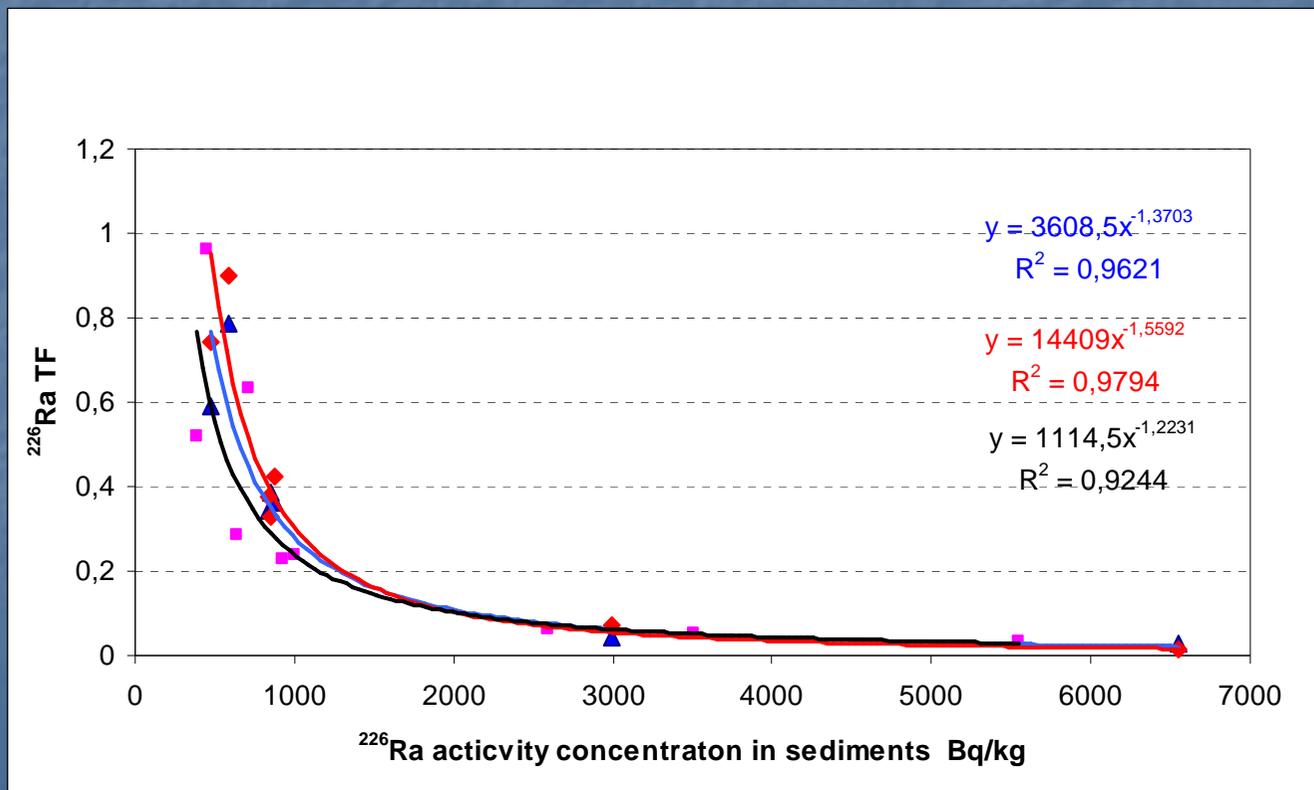
Dose rate evaluation

	committed dose rate	Total dose rate in root system	Total dose rate in upper part system
the first site	($\mu\text{Gy d}^{-1}$)		
<i>Calamagrostis epigeios</i>	63	1659	861
<i>Betula pendula</i>	9	84	47
<i>Phragmites australis</i>	7	201	104
<i>Quercus robur</i>	5	80	43
the second site	($\mu\text{Gy d}^{-1}$)		
<i>Phragmites australis</i>	5-10	55-570	30-290
<i>Lepidium ruderale</i>	7	102	54
<i>Cirsium vulgare</i>	9	46	29
<i>Matricaria perforate</i>	14	69	41

An example...

Radionuclides transfer factors into biota

- Relationship between transfer factors and radium environmental concentration is non-linear
- Transfer factors (TF) calculated on mobile fraction of radium can be three orders of magnitude higher than calculated on base of total radium concentration in sediments



Summary

- Direct contact with environment, long enough interaction makes NORM waste being an significant factor influencing ecosystem with high probability.
- Quantified effects at molecular level and the probability of their occurrence are the best measure of so called „environmental risk”

but

- **The lack of relevant regulation results in that NORM waste treatment and its environmental impact is left out of regulatory control. It results in that there are not enough efforts and resources are devoted for research on this problem ...**

in general

Adequate environment quality assessment cannot rely only on information about pollutants concentrations. It is impossible to estimate the defined above environmental risk caused by the action of a combination of agents based only on the knowledge of their concentrations in the environment.

This emphasizes the need to update some current principles of environmental standardization, which are still in use (i.e. universal clearance levels expressed as activity concentration).

A landscape photograph showing a quarry or mine site in the background with a river and reeds in the foreground. The quarry has exposed rock layers in shades of brown, red, and grey. A small waterfall flows into a river that flows through a lush green area with tall reeds in the foreground. The sky is clear and blue.

NORM waste, even now seems not to be so dangerous, is a kind of a bomb with time-delayed ignition...

Thank you for the attention