The IAEA Environmental Modelling for Radiation Safety programme (EMRAS II)

Working group on "Reference approaches to modelling for management and remediation at NORM and legacy sites"

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The EMRAS II programme

IAEA-sponsored programme

Objective: « *to improve capabilities in the field of environmental radiation dose assessment through:*

- ***Acquisition of improved data for model testing;***
- ***Reaching consensus on modeling philosophies, approaches and parameter values;***
- ***Development of improved methods and exchange of information*; »**

http://www-ns.iaea.org/projects/emras/emras2/default.asp?s=8&l=63

⇒ Follow up of previous IAEA programmes (VAMP, BIOMASS, EMRAS I)
⇒ EMRAS II ended in 2012
⇒ New programme from november 2012 (MODARIA "Modeling and Data for Radiological Assessment")

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EMRAS II working groups

Reference Approaches for Human Dose Assessment

- Working Group 1 – Reference Methodologies for "Controlling Discharges" of Routine Releases
- ***Working Group 2 – Reference Approaches to Modelling for Management and Remediation at "NORM and Legacy Sites"***
- Working Group 3 – Reference Models for "Waste Disposal"

Reference Approaches for Biota Dose Assessment

- Working Group 4 – "Biota Modelling"
- Working Group 5 – "Wildlife Transfer Coefficient" Handbook
- Working Group 6 – Biota "Dose Effects Modelling"

Approaches for Assessing Emergency Situations

- Working Group 7 – "Tritium" Accidents
- Working Group 8 – "Environmental Sensitivity"
- Working Group 9 – "Urban" Areas

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Working group 2: "NORM and legacy sites"

Scope: NORM sites (operational + legacy) + nuclear legacy sites => **existing exposure**

WG included modelers, researchers, regulators

3 plenary meetings (Vienna)

3 interim meetings

- Vienna – september 2009
- Limoges (France) – september 2010 => visit of former uranium mining and milling sites
- Brussels (Belgium) – october 2011 => visit of former radium extraction facility + phosphate processing facility

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Working group 2: “NORM and legacy sites”

Main achievements:

- Collecting data : embryo of “**catalogue**” of NORM and nuclear legacy sites;
- Review of **available models**;
- Development of **general assessment methodology** + application to real sites
- **Modeling exercises** on two specific sites: phosphogypsum stack of Gela (Italy) + uranium tailings repository of Bellezane (France)

⇒ Final report to be published as ***IAEA TECDOC***

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“NORM and legacy sites” around the world

Country	Category	Name
Argentina	U mining and milling	Los Gigantes
Australia	Nuclear legacy	Maralinga atomic bomb test site
Belgium	Nuclear legacy	Olen (radium production)
	NORM	Tessenderlo (phosphate processing)
	NORM	PG stacks, FeNb processing
Brazil	U mining and milling	Poços de Caldas
	NORM	Botuxim (monazite processing)
Bulgaria	U mining and milling	Iskra + Zvezda sites
China	NORM	Baotou sites (rare earth extraction + steel industry)
Estonia	Nuclear legacy	Paldiski (former nuclear submarine training facility)
	U mining and milling + NORM	Sillamäe (uranium tailings + rare earth)
France	U mining and milling	Uranium mining sites of Limousin
Greece	NORM	Megalopolis – coal fired power plant
	NORM	Kavala PG stack
Italy	NORM	Gela PG stack
Norway	NORM	Soeve (Niobium mining and processing)
Poland	NORM	Upper Silesia coal basin
Slovenia	U mining and milling	Zirovski waste piles
Spain	NORM	Compostilla – coal fired power plant
Ukraine	U mining and milling	Pridneprovsky plant
USA	U mining and milling	Former U mine sites on Navajo Nation

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"NORM and legacy sites" around the world

Report

⇒ *Common structure* for the description of sites (facilitates cross-comparison)

1. Description of source term: volume contaminated material, activity concentration,…
2. Description of environment and transfer parameters
3. Available monitoring data: dose-rate, ground- and surface water, radon exhalation, plants and animals,…
4. Already implemented remediation measures

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General assessment methodology

Sequential approach

1. **Identification** of the problem
2. **Preliminary site investigation** and characterization
3. **Screening assessment** using conservative assumptions and exposure scenarios
4. More **realistic assessment**
5. **Detailed assessment**
6. **Remedial** action

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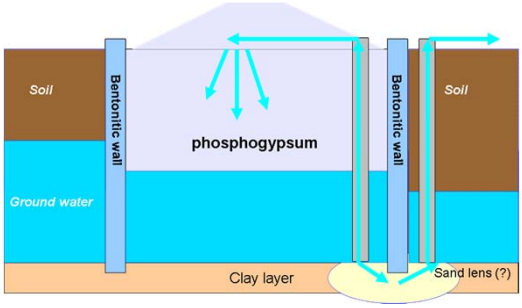
Modeling exercises – Gela PG stack

55 ha phosphogypsum stack – few hundred meters from sea coast of Sicily



Leachate collected via drainage trench
Activity concentration leachate (Bq/l):

U-238	U-234	Ra-226	Pb-210	Po-210
14	15.4	0.3	12.9	6.4

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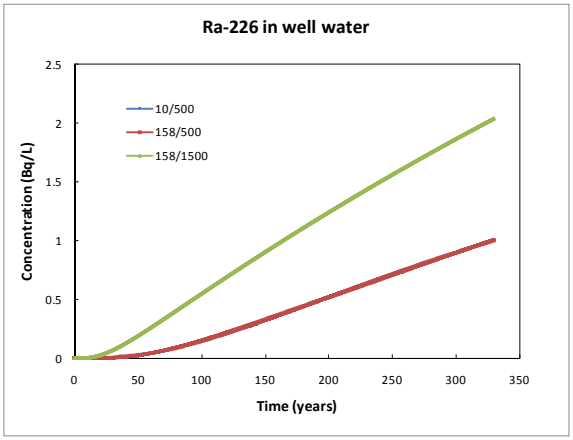
Modeling exercises – Gela PG stack

Use of RESRAD-OFFSITE (Argonne National Lab)

⇒ Calculation of Ra-226 concentration in well water without any barrier in place

⇒ Tuning of hydraulic conductivity of groundwater to reproduce 0.3 Bq/l



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Modeling exercises – Bellezane U tailings

Former open pit mines filled with U tailings (Limoges region)
Covered with ~6m waste rock layer + 0.1 m vegetal cover

Tailings: **32 Bq/g Ra-226 + 1.6 Bq/g U-238**
Waste rock: **0.5 Bq/g U-238 sec**

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Modeling exercises – Bellezane U tailings

Exposure scenarios:

1) « *Current situation* »: representative person = adult living and working in the nearby village (1 km away from the site + part of diet made of locally grown products;
2) "*Intrusion scenario*": dwelling on site – irrigation of vegetables with on-site well water;

Models used: **SATURN** (based on ECOLEGO) + **RESRAD-OFFSITE**

Current situation: very long travel time (> 40 000 yrs) of nuclides to surface and groundwater;

⇒ Trivial dose-impact

⇒ Modeling concentration: difficulties in discriminating background concentration;

Intrusion scenario: both waste rock and tailings contribute to dose

At t=0 , main contribution is radon from waste rock;
Tailings affect water-dependent pathways (dominate for t > 500 yrs)

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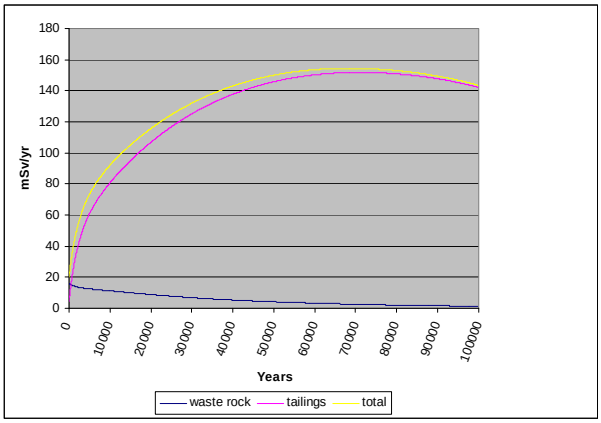
Modeling exercises – Bellezane U tailings

Contribution tailings vs waste rock



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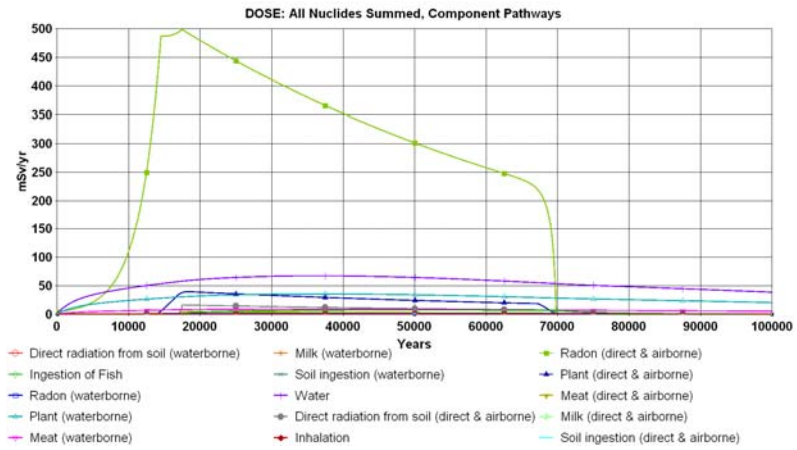
Modeling exercises – Bellezane U tailings

Suppressing the waste rock cover by playing with the erosion rate:



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Modeling exercises – Bellezane U tailings

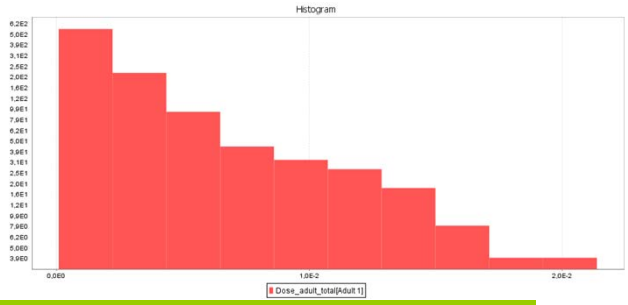
Sensitivity analysis with RESRAD-OFFSITE

⇒ Hydraulic conductivity of saturated zone + K_d in saturated zone as most critical parameters

Probability analysis with SATURN:

Assumption: K_d and transfer factor values are log-normally distributed

⇒ Histogram of dose caused by consumption of crops irrigated by contaminated groundwater (95 percentile 11 mSv/yr)



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Conclusions

Many data available

Model-model intercomparison: well-defined **conceptual model** of the site + detailed **exposure scenarios** + clear definition of **end points** modeling process

Many (unknown) parameters involved: importance of sensitivity/probabilistic analysis

NORM legacy sites: intrusion scenario as realistic assumption (concrete examples of occurrence)

How long is long term ?

Further work (MODARIA…):

=> More focus on modeling monitoring data

- Development of probabilistic calculations
- Modeling remediation actions => support for decision-making
- Cross-fertilizing between working groups (e.g. biota studies)
- …

http://www-ns.iaea.org/projects/modaria/default.asp?s=8&l=81

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