



## Radiological Aspects of Mining and Milling of Radioactive Ores and the Need to Involve Stakeholders: The WISMUT Experience

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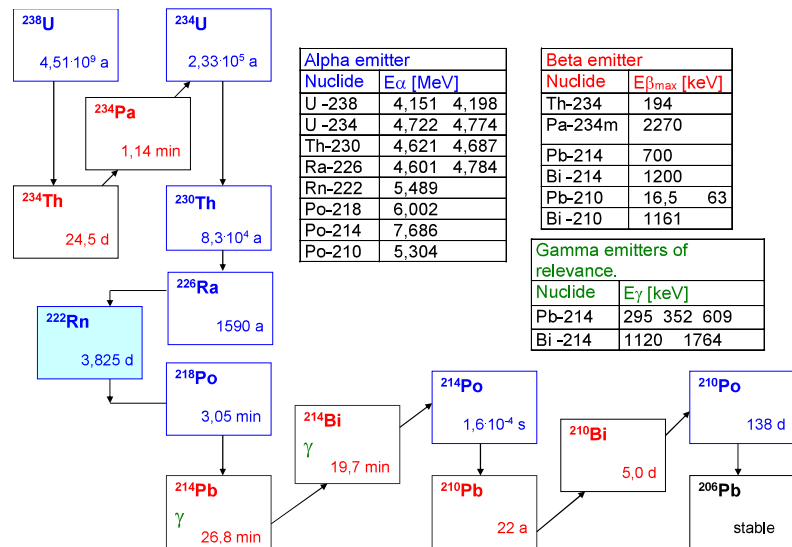
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### Structure of presentation

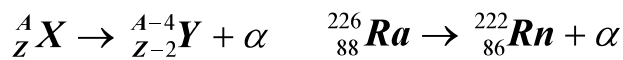
- › Radioactivity and radiation dose: a very brief introduction
- › At what point is ore radioactive ore?
- › Radiation protection (RP) principles for planned exposure situations
- › Exposure analyses – typical results at WISMUT sites and problems arising from that
- › Why stakeholder Involvement?
- › The WISMUT experience in involving stakeholders

## Radioactivity and radiation dose: a very brief introduction (1)

- Natural radioactivity: the uranium (U-238) decay chain



- Example: Ra-226



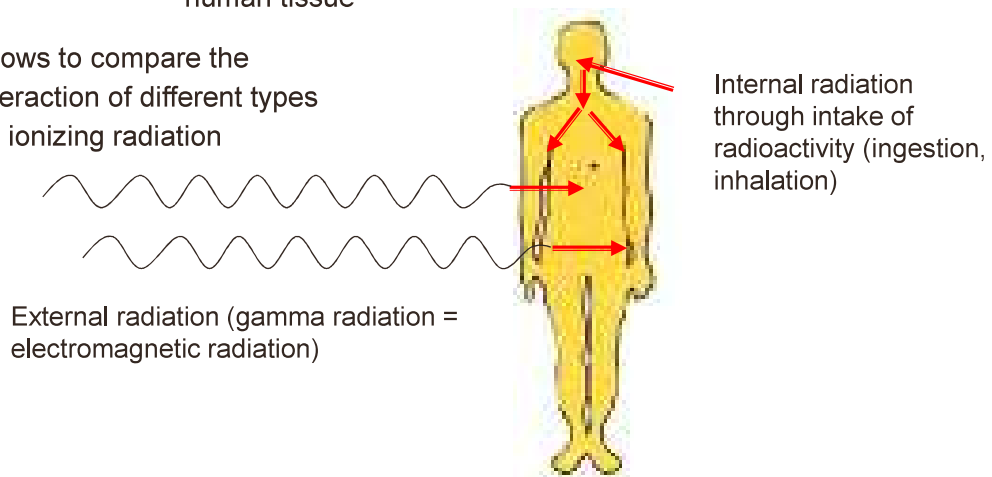
- Unit of activity: 1 per second = 1 Becquerel ( $\text{Bq} = \text{s}^{-1}$ )
- Specific activity = activity per mass unit, in  $\text{Bq/g}$



## Radioactivity and radiation dose: a very brief introduction (2)

- Effective dose:** a measure for the radiation exposure, including the biological effectiveness of radiation interaction with human tissue

- Allows to compare the interaction of different types of ionizing radiation



- Unit: Sievert (Sv), **Millisievert (mSv)**
- Effective doses (natural background) in Germany: 2 – 5 mSv/ per year



## At what point is ore radioactive ore?

- › Natural radioactivity is everywhere
- › Mean concentration of uranium in the earth crust = 3 - 4 ppm  
(particles per million)
- › 1 ppm Uranium = 12,3 mBq/g U-238
- › International Atomic Energy Agency (IAEA Basic Safety Standards) has defined as "clearance level" for each radionuclide in the uranium and thorium decay chain the value: 1 Bq/g
- › 1 Bq/g U-238 = (roughly) 80 ppm uranium

### Consequence:

- › According to international standards, ore with more than 80 ppm uranium is considered as NORM (Naturally Occurring Radioactive Material)
- › Handling of NORM (incl. mining and milling) requires radiation protection measures; the relevant national regulatory framework for NORM (if existing) has to be applied!



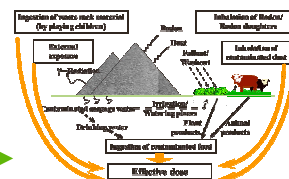
## Radiation protection (RP) principles for planned exposure situations

- › ICRP (International Commission on Radiological Protection) distinguishes the following situations:
  - Planned exposure situation (in this case: start of new mining activity)
  - Existing exposure situation (radon; remediation of legacies)
  - Emergency exposure situations (Fukushima, Chernobyl, etc.)
- › Main principles: Justification, Optimization, Limitation
- › Limitation in planned exposure situations (international standard limits):
  - 1 mSv per calendar year effective dose for members of the public
  - 20 mSv per year effective dose for occupationally exposed workers

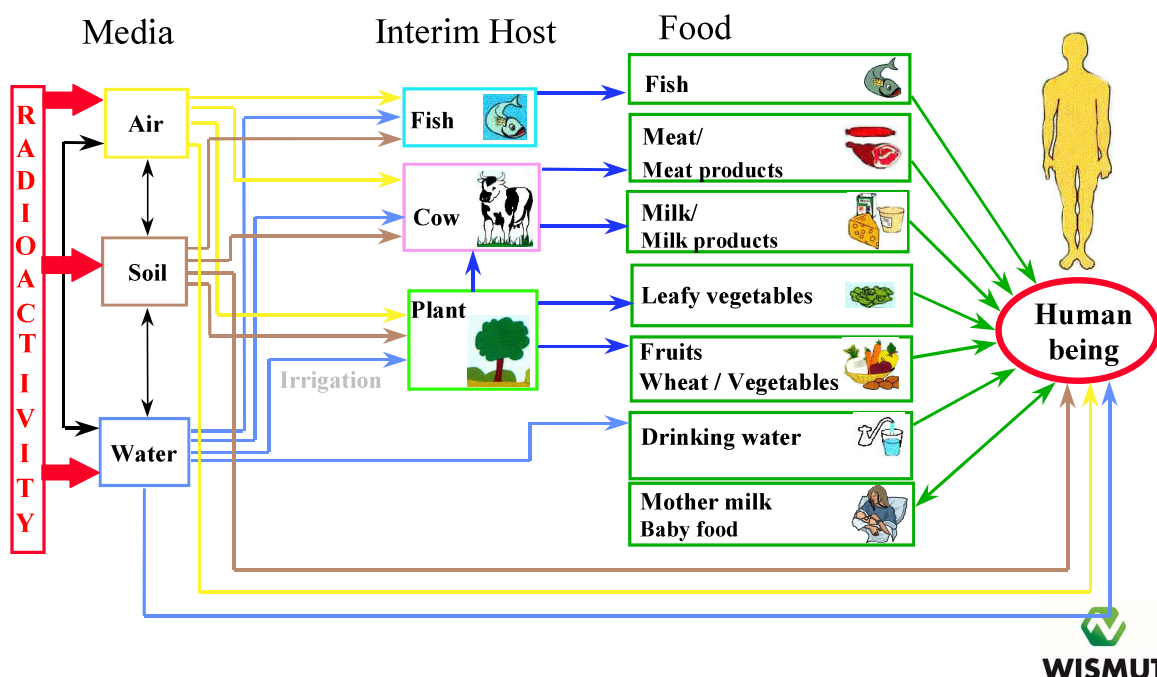


## Application of RP principles for planned mining activities (in case of NORM) - Needs

- › **Need** to apply the national regulations for RP / NORM
- › **Need** to perform an Environmental Impact Assessment (EIA) including assessment of the radiological impact (radiological risks) as part of the licensing procedure →
- › **Need** to monitor the exposure of workers (effective dose), through individual dosimetry or working place measurements
- › **Need** to develop and conduct an environmental monitoring program for the time of operation and for closure →
- › **Need** to minimize and control the dispersion of radioactivity during the mining activities (pollution management plan) →
- › **Need** to develop a waste minimization and waste management program (for mining waste in general, and for radioactive waste in particular)
- › **Need** to involve stakeholders →

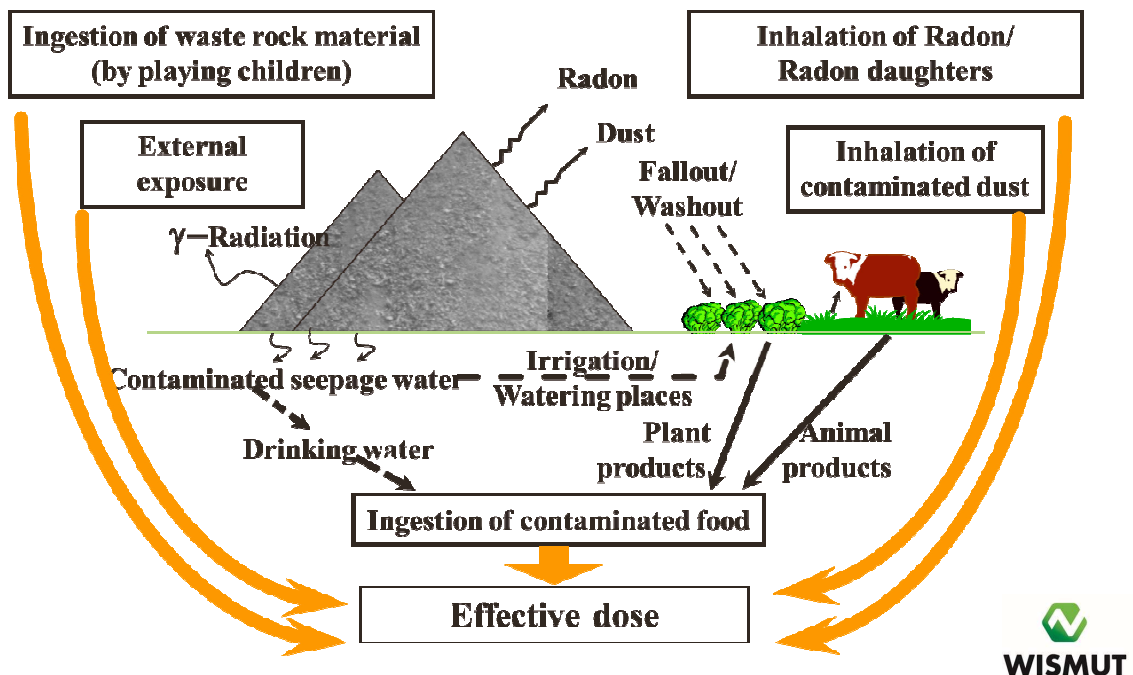


## Exposure analyses, radiological risk assessment





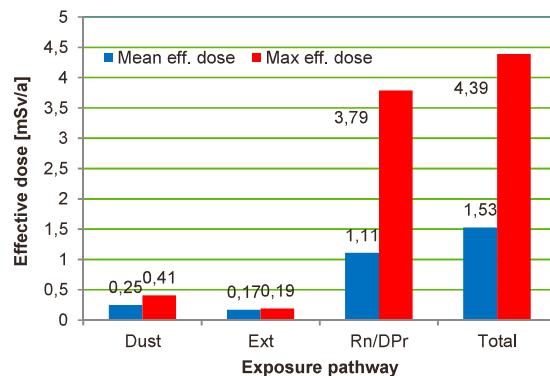
## Exposure analyses at WISMUT



## Exposure analyses - typical pattern of occupational exposure at WISMUT

Exposure of workers engaged with remediation

Underground work, Category A workers



Work on surface, Category B workers

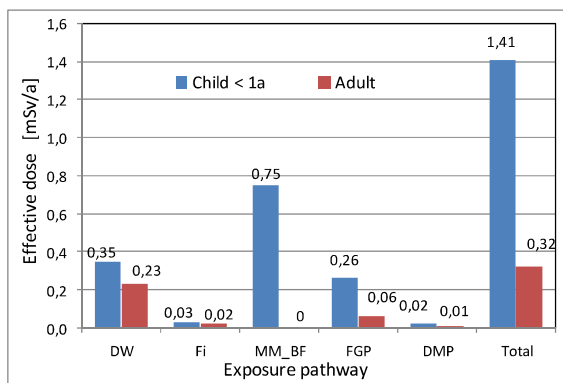


Mean effective dose: 0,70 mSv/a

Max effective dose: 1,16 mSv/a

## Exposure analyses - typical pattern of exposure of the public at WISMUT sites (water pathway)

Scenario: use of water contaminated by seepage from a tailings pond (irrigation, livestock watering, fish consumption, drinking water)



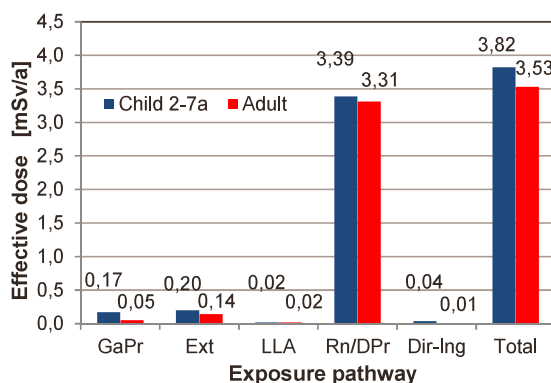
- DW - drinking water (100 %)
- Fi - fish consumption (25 %)
- MM\_BF - mother milk/baby food consumption (100 %)
- FGP - consumption of locally grown field and garden crops (25 %)
- DMP - consumption of dairy and meat products (25 %)



## Exposure analyses - typical pattern of exposure of the public at WISMUT sites (air pathway)

### Living in a house close to a waste rock pile

- waste rock: 0,6 Bq/g U-238, radioactive equilibrium
- ambient gamma dose rate: 450 nSv/h at the dump
- Rn: 280 / 200 Bq/g m<sup>3</sup> on the pile / at the pile toe
- C<sub>IIA</sub>: 1 mBq/m<sup>3</sup>; dust precipitation at garden areas
- minus background (site specific: e. g. 30 Bq/m<sup>3</sup> Rn)



- GaPr - consumption of locally grown garden products (50 %)
- Ext - external radiation
- LLA - inhalation of long-lived alphas
- Rn/DPr - inhalation of Radon/Rn daughters
- Dir-Ing. - direct ingestion



## Why stakeholder involvement?

### › Lessons learnt from the past

- Mining activities have been increasingly losing acceptance among the population, mainly due to past environmental pollutions, failure to address social issues, legacies without programs of remediation, ...
- Start of new mining activities without clear assessment of potential impacts on humans and environment and without a clear perspective for the time after mining will not work
- In case radioactivity comes in place, the acceptance of any activities is additionally decreased on side of a number of stakeholders
- IAEA, OECD, NEA and consider stakeholder involvement as one of the most important elements in decision making

### › Stakeholders

- Operator, regulator, local public, municipalities, donators / funding organizations, press, scientific communities, NGO's



## The WISMUT strategy for involving stakeholders and for building bridges with the public

- › „Playing with open cards“; openness, frankness, - in particular disclose of data on environmental pollution
- › Involvement of the local public in decision making; stakeholder involvement in general
- › Active public relation policy (annual environmental reports, open house days, WISMUT exhibition at each site, events under WISMUT umbrella, ..)
- › Preservation of mining traditions (since 2019, the WISMUT sites are part of the UNESCO world culture heritage “Erzgebirge/Krušnohoří Mining Region”)
- › Developing of the local workforce
- › Returning the WISMUT legacy to productive use, in line with regional development plans and local stakeholder interests





## For illustration: Building bridges with the public



Information for the public



Open house day (annually)



WISMUT exhibition, Ronneburg site



“Haldenlauf” – annual run over a remediated waste rock pile



International Mining Symposium WISSYM (every three years)



Preservation of mining traditions, annual miners procession in Schlema



**Thank you very much for your kind attention. Glückauf!**

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## ... and what you can learn from!

- › plan with the closure in mind from day one
- › avoid future legacies
- › perform mining and milling sustainabl
- › Invest in prevention of long-term liabilities
- › start early with site clean-up
- › concerning the closure plan
  - see your site as a whole (conceptual site model)
  - take care of uncertainties in data & knowledge
  - beware of extreme events (e.g. floods)
- › understand early involvement of stakeholders as a key of acceptance and sucessful performance

