Practical experience from Norway in NORM remediation

DSA

Direktoratet for strålevern og atomsikkerhet

Norwegian Radiation and Nuclear Safety Authority

Overview

- → NORM in Norway
- → Potentially acidifying rocks
- → When the risk is not accepted
- → Environmental hazards and risks
- → Ecosystem assessments in a multiple stressor environment
- → Economical consequences
- → Need for specialized knowledge
- → What is enough knowledge to base a decision on?
- → Conclution

NORM in Norway

- Based on the list of NORM-industries from the EU and IAEA, there are quite a few NORM-industries in Norway
  - Petroleum (oil and gas)
  - Minerals (titaniumdioxide, REE – potential future industry)
  - Metal mining and milling (molybdenum/Niobium smelter residues)
  - Fertilizer (phosphate industry)
- Also several cases where natural processes caused formation of NORM pollution or waste
  - Groundwater on the outside of tunnells
  - Acid mine drainage from abandoned mines
  - Potentially acidifying rocks

Potentially acidifiying rocks (PAR)

- → The absolutely largest volume of Norwegian radioactive waste is potentially acidifying rocks
- → Black shales with an acid forming potential
- → Chemically reactive, exothermic oxidative reactions
- → Contains a long list of heavy metals, including U and Th
- → A source of radon
- → Large potential for pollution and therefore a form of waste regulated by the pollution control act and waste regulations
- → Relatively expensive and challenging to handle compared to other types of rock

When the risk is not accepted

→ As for most (if not all) regulators, we experience that the responsible party sometimes do not want to do expensive actions and try to find alternative ways to handle wastes

→ One challenge for the regulator is that PAR is «everywhere» and we are depending on the entreprenours to act in accordance with legal requirements – not just to their best understanding

→ Wastes from nuclear installations, research and hospitals and so on are accounted for, PARs are not necessarily accounted for

→ When the responsible party don’t think the hazards applies for their wastes, the search for alternative ways to handle wastes can cause unsafe ways to handle these wastes.

Environmental hazards and risks

- Potentially acidifying rocks has an intrinsic hazard with regards to the chemical reactivity and potential for release of heavy metals and radionuclides
- The risk from these wastes comes when the responsible party do not handle these wastes in a safe manner
- Unsafe handling is any action that causes «fresh» PAR to be exposed to oxygen and water
- The consequences – leaching of uranium and potential exposure for biota to radiation

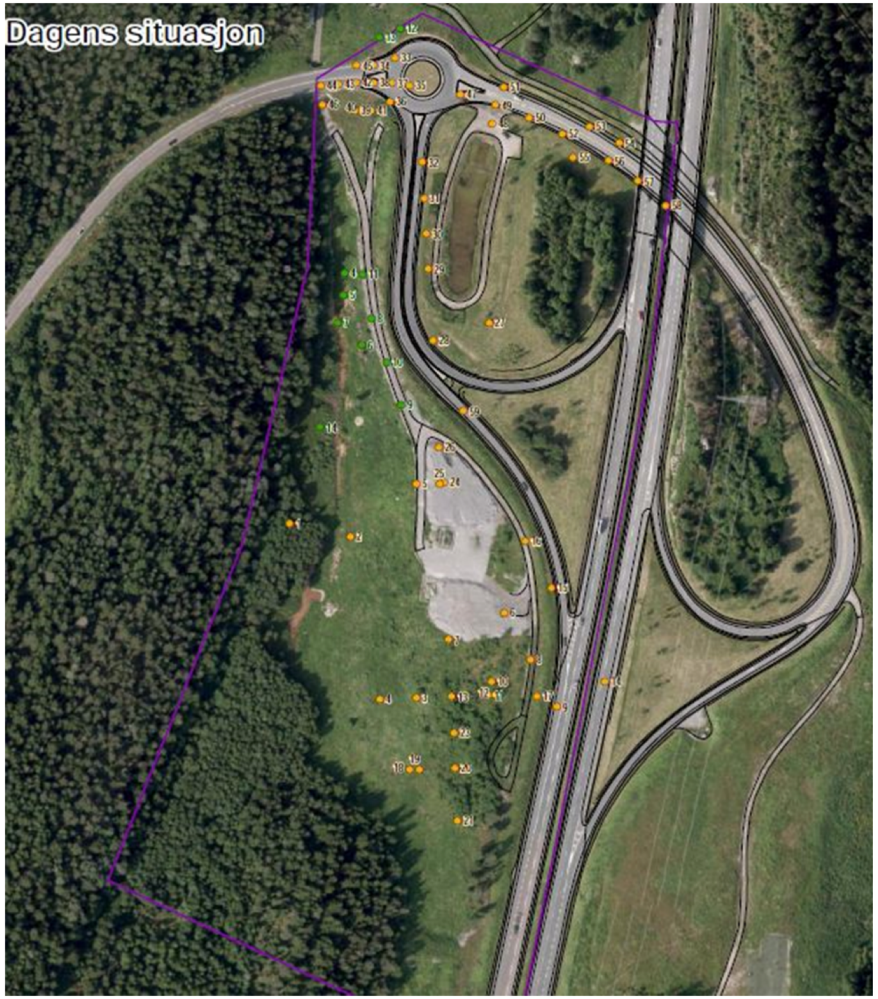
Ecosystem assessments in a mulitple stressor environment

- → Important to work together with other environmental protection authorities – mutual support and sharing experience
- → Exposure to heavy metals and acid causes more acute toxicity
- → Even though other contaminants are more acutly toxic, it is still not ok to further contaminate areas with radionuclides
- → Modeling tools for multiple stressors are needed

ELEMENT	SAMPLE	742 Sigev	743 Sigev	744 Sigev	745 Sigev	747 Sigev	748 Sigev	749 Sigev	750 Sigevar
pH		6,72	5,18	3,26	3,26	3,2	3,3	5,72	3,18
Ledningsevne (l	mS/m	225	186	205	190	201	183	202	232
Ca (Kalsium)	mg/l	357	219	203	171	187	179	245	219
Fe (Jern)	mg/l	1,88	7,1	20,5	17,1	18,4	11,1	11,7	25,6
K (Kalium)	mg/l	15,6	22,4	11,7	10	10,5	10,6	27,7	11,2
Mg (Magnesium)	mg/l	144	123	129	110	123	106	136	148
Na (Natrium)	mg/l	17,5	26,4	14,6	11,8	12,4	9,87	32,9	14,8
Al (Aluminium)	µg/l	63,5	6900	19400	17000	19200	15500	7830	25400
As (Arsen)	µg/l	0,694	0,663	0,751	<0.5	<0.5	<0.5	1,1	<0.5
Ba (Barium)	µg/l	84,4	59,4	46,9	40,7	42,7	38,4	71,4	49,7
Cd (Kadmium)	µg/l	12,4	69,4	82,4	69,8	78,1	55,2	74,9	98,8
Co (Kobolt)	µg/l	75,9	260	314	260	301	235	281	355
Cr (Krom)	µg/l	<0.9	1,02	5	4,4	4,76	4,06	1,66	6,39
Cu (Kopper)	µg/l	3,72	425	626	510	563	411	447	765
Hg (Kvikksølv)	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mn (Mangan)	µg/l	10200	10700	11900	10400	11900	9970	12800	14800
Mo (Molybden)	µg/l	2,19	1,26	<0.5	<0.5	<0.5	<0.5	2,44	<0.5
Ni (Nikkel)	µg/l	909	2040	2350	2030	2240	1800	2090	2690
Pb (Bly)	µg/l	<0.5	<0.5	0,977	0,97	1,05	1,43	<0.5	1,39
Zn (Sink)	µg/l	1510	3340	3490	3380	3780	2890	3440	4450
V (Vanadium)	µg/l	<0.2	<0.2	0,243	<0.2	<0.2	<0.2	0,23	<0.2
Sb (Antimon)	µg/l	0,259	0,173	0,118	0,137	0,109	0,123	0,193	0,118
Se (Selen)	µg/l	<3	<3	<3	<3	<3	<3	<3	<3
Sr (Strontium)	µg/l	1220	929	866	743	803	740	1030	951
Si (Silisium)	mg/l	8,03	9,25	9,98	8,62	9,48	8,35	10,3	11
B (Bor)	µg/l	<100	<100	<100	<100	<100	<100	<100	<100
Th (Thorium)	µg/l	<0.2	0,426	5,93	7,94	9	5,86	1,63	11,3
U (Uran)	µg/l	7,09	121	204	170	192	144	117	241
Klorid (Cl-)	mg/l	10,7	11,6	9,18	8,23	11,6	8,12	13,6	10,5
Fluorid (F-)	mg/l	0,568	0,883	1,96	2,53	2,13	2,68	2,16	3,69
Sulfat (SO4)	mg/l	1170	999	1070	979	1140	1130	1290	1480
DOC	mg/l	4,77	8,06	4,74	4,35	3,82	5,64	9,52	4,05
P-total	mg/l	<0.050	0,123	0,118	0,108	0,069	0,163	0,099	0,067
S (Svovel)	mg/l	540	403	386	379	374	375	389	597
TOC	mg/l	4,92	8,26	4,92	4,5	3,88	5,67	10,3	4,16
Alkalinitet pH 4.5	mmol/l	2,77	<0.150	<0.150	<0.150	<0.150	<0.150	0,743	<0.150
Alkalinitet pH 8.3	mmol/l	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Turbiditet	FNU	8,27	47,8	65,1	31,9	36,6	32,4	114	70,8
Suspendert stof	mg/l	16,7	49,4	27,8	18,3	17,5	19,9	80,8	26,2
N-total	mg/l	0,72	0,42	0,35	0,13	0,17	0,11	0,66	0,16
Nitrat-N (NO3-N	mg/l	0,586	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Fosfat (ortofosfa	mg/l	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040

Economical consequences

- → Some remediation actions may be quite expensive
  - → One case where PARs are under a road. Removal and rebuilding of roads are intrinsically expensive. Challenging geology – for instance quick clay
- → How to assess economical value of the environment against the cost of remediation?



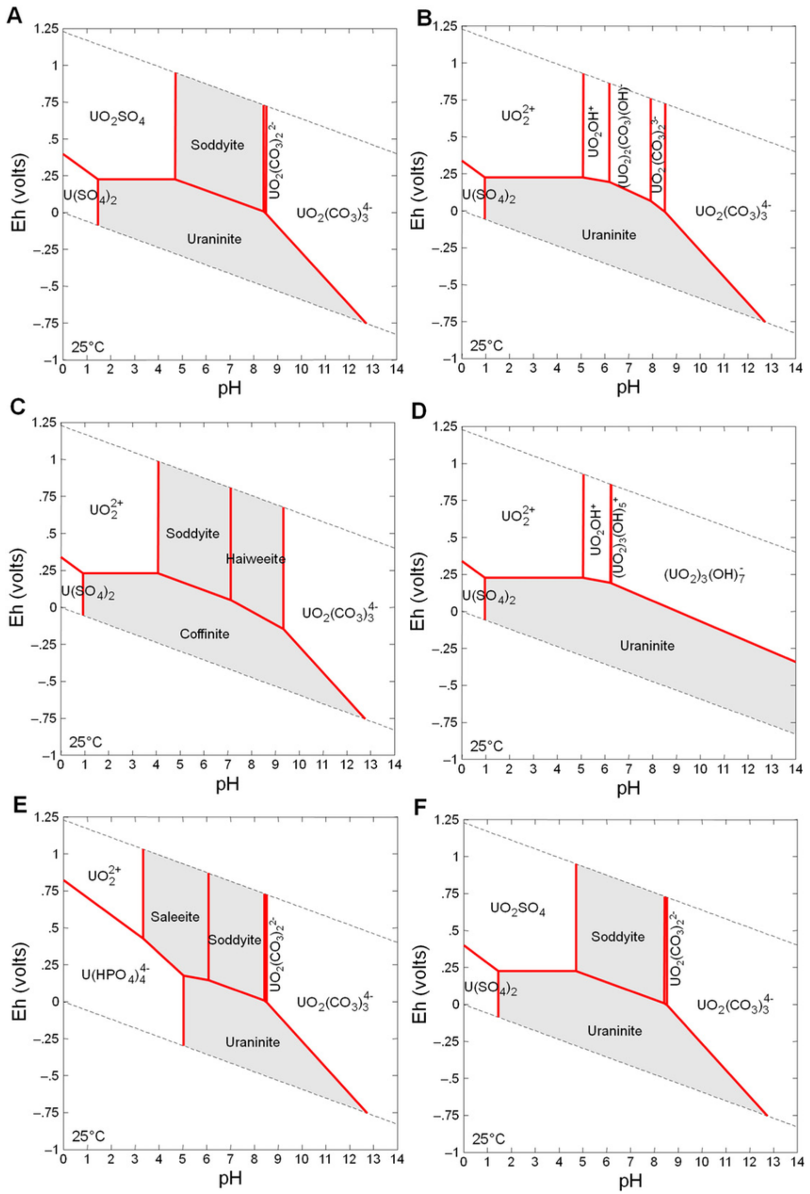
Need for specialized knowledge

→ Complicated assessments with regrads to chemical behavior of NORM

→ Varying degree of knowledge – not easy to find qualified consultants for the enterprises

→ Challenging to communicate hazards, risks and the need for necessary countermeasures

$$UO_2 + 2\,Fe^{3+} = UO_2^{2+} + 2\,Fe^{2+}$$



What is enough information to base a decision on?

- The foundation of a decision needs to be good enough to weigh the need for remediation actions against cost (cost/benefit)
- Again – how to assess value of the environment in itself
- Demands in Norwegian legislation to sufficiently evaluate the fact of the cases
  - Yet – it is also a legislative claim that even in cases where the knowledge is somewhat limited, this cannot be enough to not to necessary remediation actions
- Must assume that decisions will be subject of complaint – all involved parties need sufficient knowledge of NORM pollution and wastes

The need to provide enough (and understandable) guidance

- → DSA has experienced that good and understandable guidance can save time and money
- → In the process of developing guidance documents. Used recommandations from IAEA, looked through our earlier cases. Requested and got input from international experts, other Norwegian Environmental Agencies and some selected companies that has had cases with NORM handling and/or remediation earlier.
- → May be a little too detailed…

Conclution

→ NORM remediation is:
  → Challenging
  → Expensive
→ NORM remediation is necessary in some cases despite its challenges and expenses
→ Must expect that the decisions will be subject to complaints

Thank you for your attention

Points of contact:
Lene Valle, senior adviser, lene.valle@dsa.no
Ingeborg Mork-Knutsen, head of section, ingeborg.mork-knutsen@dsa.no