Tessenderlo’s CaF_2 sludges dumpsites (Tessenderlo – Belgium)

1. General description

Tessenderlo is located in North East Belgium. The chemical company Tessenderlo Chemie treats Moroccan phosphate ore for the production of cattle food. It uses the hydrochloric acid process which results in the production of solid waste which consists predominantly of CaF_2 sludges. Several dumpsites have been exploited by the company. One of them consists of three separate disposal sites next to each other (see map in § 2): S1, S2 and S3. S1 is not in exploitation anymore. S2 and S3 are still in exploitation. The site S1 made the object of the EC report “*Radiation protection 115: Investigation of a possible basis for a common approach with regard to the restoration of areas affected by lasting radiation exposure as a result of past or old practice or work activity*” [1]

2. Source term

2.1 Layout of the site

The *Veldhoven* dumpsite is located just North of a canal (“*Albert canal*”) and is made of three distinct exploitation areas, S1, S2, S3. As shown on the figure below [2], there is another dumpsite (no more in exploitation) just on the other side of the canal, located on the factory premises.

	Area (ha)	**Volume of residues (tons)**	**Years of exploitation**
S1	25	900 000	1963 - 1986
S2	4	50 000	(buffer dump) ~ 1980 - today
S3	26	900 000	1987 - today
Dumpsite on factory premises	5.6	150 000	1935 - ~ 1970

The total capacity of the S3 dump amounts to ~ 2,400,000 m^3. The density of the sludge is around 1.6 ton/m^3.
Note that there are two others disused dumpsites located 1 – 2 km SW of the *Veldhoven* site.

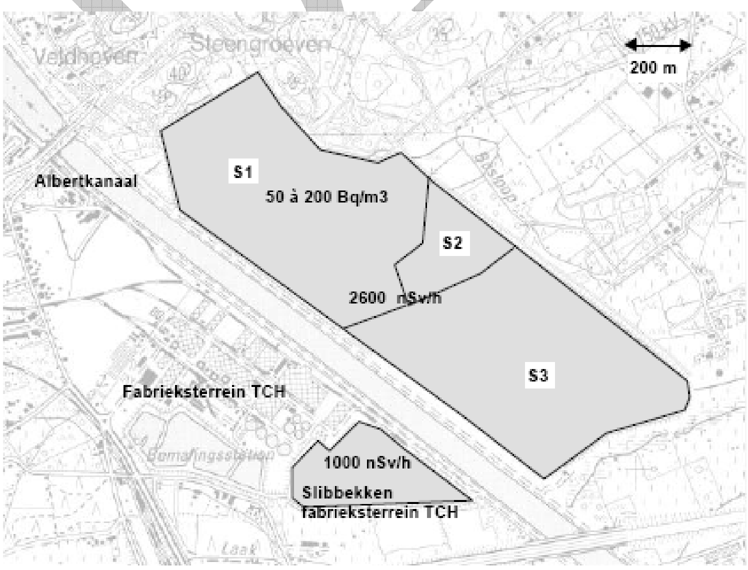

Fig. 1: Layout of the site

See also “googlemaps”:
http://maps.google.be/maps/ms?msa=0&msid=103096293426062338799.00047b660c2e72ad902de&hl=fr&ie=UTF8&t=h&ll=51.091933,5.158167&spn=0.037736,0.076818&z=14

2.2 Radiological data

Till 1995, the average Ra-226 concentration in the CaF_2 sludges was ~3.5 Bq/g. Since 1995, the Ra-226 concentration[1] has significantly increased up to ~ 11 Bq/g. The Ra-226 concentration on the S3 dumpsite is thus significantly higher than on the other sites (which have been abandoned before 1995).

A radon monitoring program has been set up on and around the dumps. There are 14 measurements points; the figure below shows the location of these points and the table shows the results of the measurements from 2004 to 2006 (data from 1993 to 2004 are also available if needed).

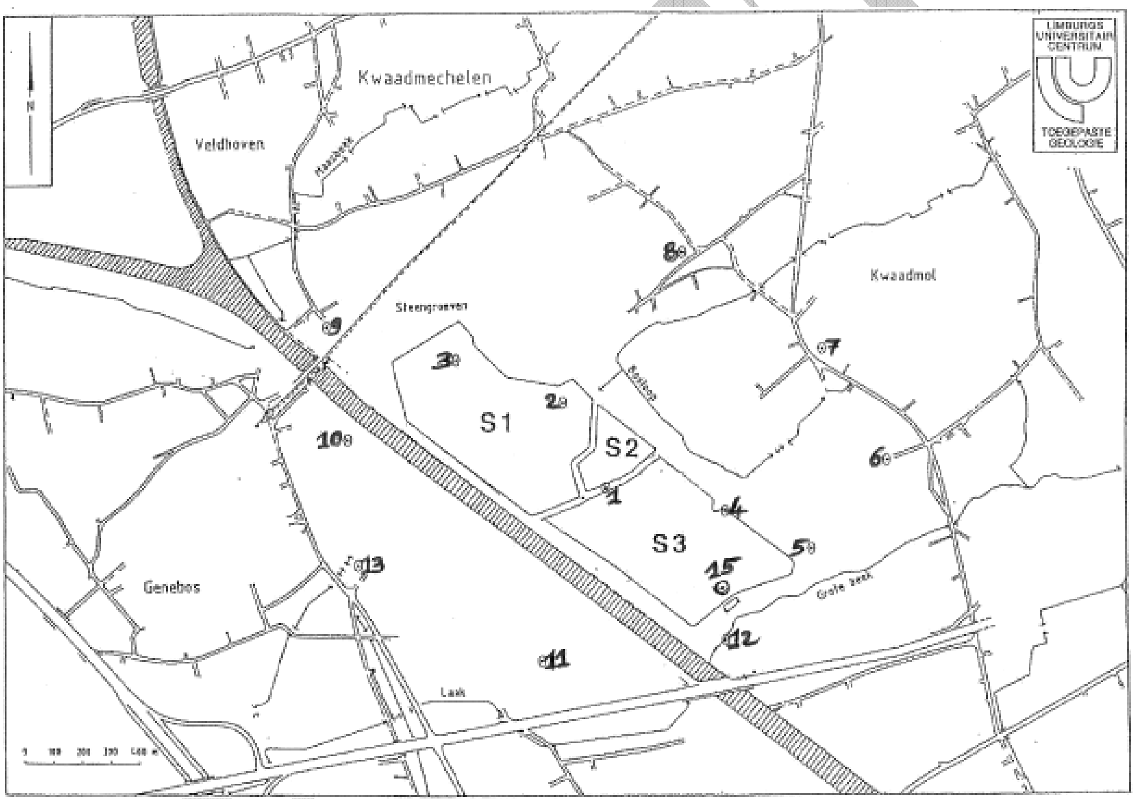

Fig. 2: location of the radon measurements points.

	1st semester 2004	**2nd semester 2004**	**1st semester 2005**	**2nd semester 2005**	**1st semester 2006**	**2nd semester 2006**
A. On the dumpsites S1 and S2						
1	150	130	115	205	145	155
2	145	195	180	245	175	255

[1] In order to decrease the radium concentration in waste water, baryum has been added to the process in order to co-precipitate radium. This process was very efficient in reducing the radium concentration of waste waters but led to an increase of the radium concentration in solid waste.

3	310	310	290	495	380	480
B. On dumpsite S3						
4	60	100	105	40	45	35
15	75	65	65	65	65	135
C. In the surroundings						
5	35	35	40	25	35	25
6	20	20	15	10	20	15
7	25	30	25	15	40	20
8	20	20	20	15	25	15
9	35	20	30	25	30	25
10	55	30	55	35	60	25
11	-	160	135	-	205	
12	55	30	40	30	35	45
13	25	25	40	20	35	30

NB: All results in Bq/m^3

3. Site data

3.1 Surface waters + (hydro-)geology

In addition to the canal, there are two small rivers flowing next to the dump site (~ 50m away from the site): "*Bosloop*" to the NE (it follows the edge of S2 and S3) and "*Grote Beek*" (SE of S3). According to piezometrical measurements, groundwater flows in the direction of the "*Grote Beek*" river.

Flowrate of "*Grote Beek*": 2000 m^3/hour.

Nature of soil under dumpsite: sandy

Groundwater:
- Cross sectional area: 2600 m^2
- Flow rate: 10 m/y

3.2 Distribution coefficients

There are no site-specific distribution coefficients available. The following values have been used in [1]:

Nuclide	**Half life (years)**	**Gross average distribution coefficient (K_d) values (m^3/kg)**			
		sandy soils		**aqueous system sediments**	
		best estimate	**range**	**best estimate**	**range**
Po-210	0·38	0·15	0·006 - 3·6	0·15	0·006 - 3·6
Pb-210	22·3	0·27	0·0027 - 27	0·27	0·0027 - 27
Ra-226	1600	0·49	0·00082 - 300	0·5	0·1 - 1
Ra-228	5·75	0·49	0·00082 - 300	0·5	0·1 - 1
Th-228	1·91	3·0	0·045 - 200	10	1 - 1000
Th-232	$1·41 \times 10^{10}$	3·0	0·045 - 200	10	1 - 1000

3.3 Transfer factors

The transfer factors used in [1] are reproduced below. They are not site-specific.

Element	Transfer factors (and ranges) for pasture grass and agricultural crops Bq/kg (dry plant) per Bq/kg (dry soil)			
	Grass	**Leafy vegetables**	**Roots vegetables**	**Grain**
Po	$9{\cdot}0\times10^{-2}$ $(9{\cdot}0\times10^{-3} - 9\times10^{-2})$	$1{\cdot}2\times10^{-3}$ $(1{\cdot}2\times10^{-4} - 1{\cdot}2\times10^{-3})$	$7{\cdot}0\times10^{-3}$ $(7{\cdot}0\times10^{-4} - 7{\cdot}0\times10^{-3})$	$2{\cdot}3\times10^{-3}$ $(2{\cdot}3\times10^{-4} - 2{\cdot}3\times10^{-3})$
Pb	$1{\cdot}1\times10^{-3}$ $(1{\cdot}1\times10^{-4} - 1{\cdot}1\times10^{-2})$	$1{\cdot}0\times10^{-2}$ $(5\times10^{-4} - 2\times10^{-1})$	$2{\cdot}0\times10^{-2}$ $(2{\cdot}0\times10^{-4} - 2{\cdot}0\times10^{-1})$	$4{\cdot}7\times10^{-3}$ $(4{\cdot}7\times10^{-4} - 4{\cdot}7\times10^{-2})$
Ra	$8{\cdot}0\times10^{-2}$ $(1{\cdot}6\times10^{-2} - 4{\cdot}0\times10^{-1})$	$4{\cdot}9\times10^{-2}$ $(2{\cdot}5\times10^{-3} - 9{\cdot}8\times10^{-1})$	$1{\cdot}1\times10^{-3}$ $(2{\cdot}2\times10^{-4} - 1{\cdot}1\times10^{-1})$	$1{\cdot}2\times10^{-3}$ $(2{\cdot}4\times10^{-4} - 6{\cdot}0\times10^{-3})$
Th	$1{\cdot}1\times10^{-2}$ $(1{\cdot}1\times10^{-3} - 1{\cdot}1\times10^{-1})$	$1{\cdot}8\times10^{-3}$ $(4{\cdot}5\times10^{-5} - 7{\cdot}2\times10^{-2})$	$5{\cdot}6\times10^{-5}$ $(5{\cdot}6\times10^{-6} - 3{\cdot}9\times10^{-1})$	$3{\cdot}4\times10^{-5}$ $(3{\cdot}4\times10^{-6} - 8{\cdot}5\times10^{-4})$

Element	Transfer factors (and ranges) for animal foodstuffs Bq/kg or /L (animal foodstuff) per Bq/kg (dry food) per kg/day (dry food intake)		
	Beef	**Milk**	**Pork**
Po	$5{\cdot}0\times10^{-3}$ $(6\times10^{-4} - 5\times10^{-3})$	$3{\cdot}4\times10^{-4}$ (n/a)	$2{\cdot}5\times10^{-2}$ (n/a)
Pb	$4{\cdot}0\times10^{-4}$ $(1\times10^{-4} - 7\times10^{-4})$	$3{\cdot}4\times10^{-4}$ (n/a)	$2{\cdot}0\times10^{-3}$ (n/a)
Ra	$9{\cdot}0\times10^{-4}$ $(5\times10^{-4} - 5\times10^{-3})$	$1{\cdot}3\times10^{-3}$ $(1\times10^{-4} - 1{\cdot}3\times10^{-3})$	$4{\cdot}0\times10^{-3}$ (n/a)
Th	$2{\cdot}7\times10^{-3}$ (n/a)	$5{\cdot}0\times10^{-4}$ (n/a)	$2{\cdot}0\times10^{-2}$ (n/a)

Element	Transfer factors (and ranges) for aquatic foodstuffs Bq/kg per Bq/m^3 (water)			
	Freshwater fish	**Marine fish**	**Crustacea**	**Molluscs**
Po	0·05 (0·01 - 0·5)	2·0 (n/a)	50·0 (n/a)	10·0 (n/a)
Pb	0·30 (0·1 - 0·3)	0·20 (n/a)	1·00 (n/a)	1·00 (n/a)
Ra	0·05 (0·01 - 0·2)	0·50 (n/a)	0·10 (n/a)	1·00 (n/a)
Th	0·10 (0·01 - 10)	0·60 (n/a)	1·00 (n/a)	1·00 (n/a)

Consumption		Dairy cattle (milk yield: 10-20 L/day)		Beef cattle (500 kg)		Swine (110 kg)	
		best estimate	**range**	**best estimate**	**range**	**best estimate**	**Range**
Water	m^3 /day	0·075	0·05-0·10	0·040	0·02-0·06	0·008	0·006-0·01

Soil	Kg/day	0·64	0·4-10	0·3	0·2-0·4	0·48	0·4 - 0·6
Cereal	kg/day dw	0	0	0	0	2·4	2·0-3·0
Grass	kg/day dw	16·1	10-25	7·2	5-10	0	0

4. Radiological assessment

The dumpsite S1 has been used as a test case for the generic assessment methodology described in the EC report "*Radiation protection 115: Investigation of a possible basis for a common approach with regard to the restoration of areas affected by lasting radiation exposure as a result of past or old practice or work activity*" [1]. In this report, a generic assessment model has been developed (AMCARE: Assessment Model for a Common Approach to REstoration of contaminated sites).

This report may be downloaded from:

http://ec.europa.eu/energy/nuclear/radiation_protection/doc/publication/115.pdf

Section 5.3.2 of the report (pp. 20 – 26) describes all parameters values of the model (nuclide specific distribution coefficient, transfer factors pasture grass and agricultural crops, transfer factors for animal and aquatic foodstuffs, critical group characteristics, etc.).

Two exposure scenarios have been considered (see p. 17 of report):

i) a *normal evolution case*, with farmers residing and working close to the site ("status quo" in the site and local population characteristics)

ii) an *intrusion scenario*, where members of the critical group inhabit houses built directly on the contaminated site.

The results of the dose assessment for these two scenarios are described in details in section 5.3.3 (p. 26) and 5.3.4 (p. 29) of the report.

Radon inhalation is by far the main exposure pathways for the two scenarios. For the normal evolution scenario, it leads to a dose of 0.5 mSv/y. For the intrusion scenario, it leads to a dose of 357 mSv/y.

5. References

[1] "Radiation protection 115: Investigation of a possible basis for a common approach with regard to the restoration of areas affected by lasting radiation exposure as a result of past or old practice or work activity", CARE final report, H. Vandenhove, A. Bousher, P. Hedemann Jensen, D. Jackson, B. Lambers, T. Zeevaert, report prepared for European Commission DG XI, September 1999.

[2] "Inventarisatie en karakterisatie van verhoogde concentraties aan natuurlijke radionucliden van industriële oorsprong in Vlaanderen", J. Paridaens and H. Vanmarcke, June 2001 (in Dutch).