Olen: dumpsites of a former radium extraction facility (Olen – Belgium)

1. General description

A metallurgical company located in Olen has extracted radium from minerals and produced radium sources from 1922 till 1969. Besides radium extraction activities, this company was also active in the production of other metals, especially cobalt. Wastes have been essentially dumped onto two dumpsites: the so-called D1 and S1 dump. The D1 dump shows the greatest contamination (with hot spots up to ~1 MBq/kg of Ra-226). Moreover the banks of a nearby river and some streets of the surrounding town were also contaminated: a remediation project has however recently been carried out for these last parts of the contamination. The dumpsites have still to be remediated.

This site was already used as test-case in the framework of the BIOMASS IAEA program [1]. However, this report focused on the part of the site which was contaminated through the liquid effluents (via flooding and dredging of sediments) of the former plant. The dumpsites were not included in the study.

2. Source term

2.1 Layout of the site

The D1 dump is located along a canal ("*Herentals-Bocholt canal*"). It contains iron hydroxide and calcium sulfate coming from the non-ferrous activities, residues from radium extraction and rubbles from the dismantling of buildings from the radium facility.

The S1 dump is located on the other side of the canal – inside the factory premises. It contains mainly residues (iron hydroxide and calcium sulfate) from the cobalt production facility and radium contaminated dredging sludges from the nearby river ("Bankloop").

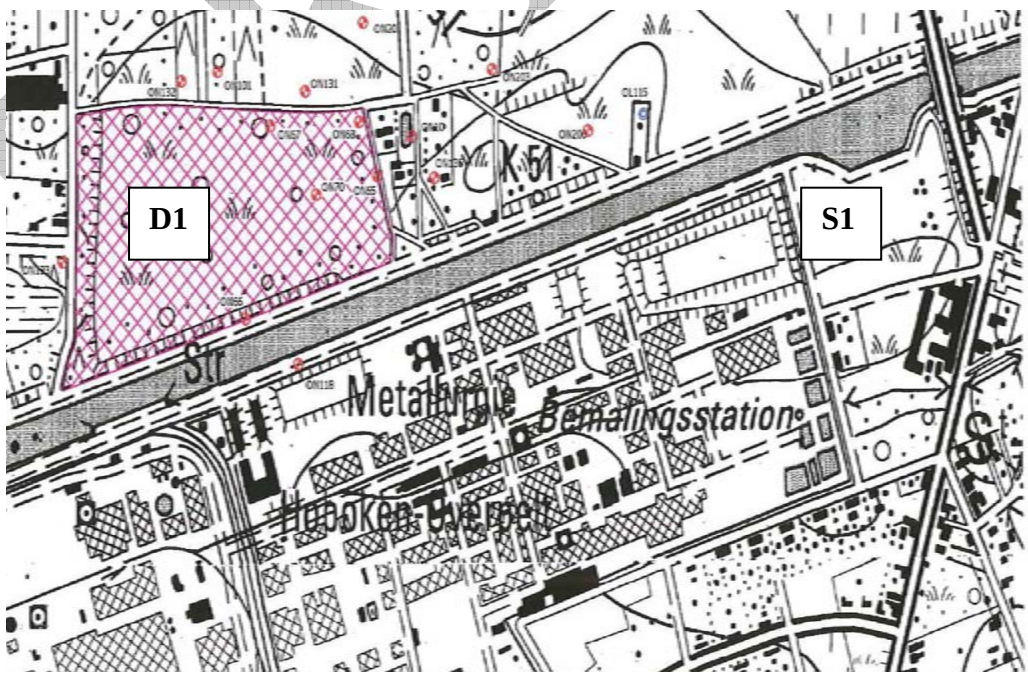

Fig. 1: Layout of site

An aerial view of the site may also be found on googlemaps:
http://maps.google.be/maps/ms?msa=0&msid=103096293426062338799.00047b660c2e72ad902de&hl=fr&ie=UTF8&ll=51.185257,4.90365&spn=0.037659,0.076818&t=h&z=14

The site is just to the left of the town “Sint Jozef Olen”.

D1 dump:
- **area** : ~ 10 ha
- **volume waste**: 217,000 m^3

The width of the waste layer varies between 0 and 3 m. The hydraulic conductivity of the dumped sludge is small: **$k = 1 – 1.5\ 10^{-8}$ m/s**.

S1 dump:
- **area:** ~ 2.4 ha (240 X 100 m)
- **volume waste**: 207,000 m^3

The height of the dump is ~15m.

2.2 Radiological data

2.2.1 D1 dump

The radium concentration is highly inhomogeneous with activities ranging from 40 Bq/kg up to 930 kBq/kg. The average value for Ra-226 on the whole volume of the dump has been evaluated to ~20 Bq/g[1]. The activity of U-238 is ~ 200 Bq/kg but the activity of Th-230 is similar to and in some cases higher than the activity of Ra-226. Th-232 and its daughter nuclides were not detected above natural background levels. Fig. 2 shows the maximum dose rate in the interval 50-100cm below the surface of the dump.

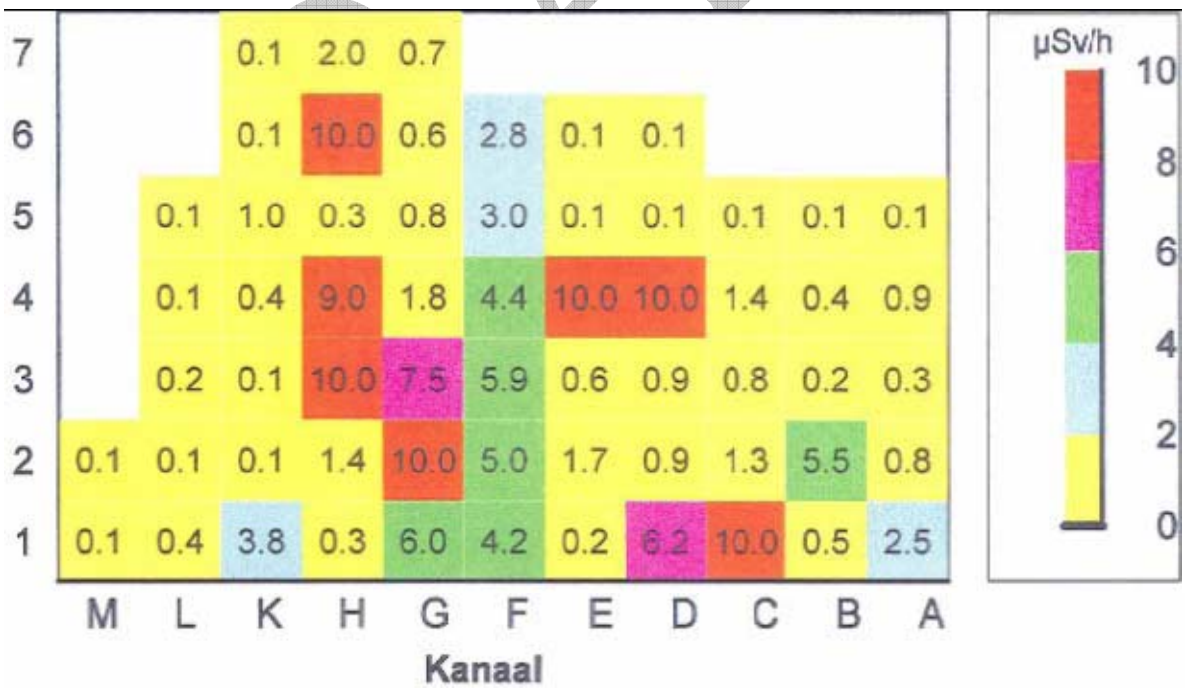

Fig. 2: Maximum dose rates measured downhole in the interval 50-100 cm below the ground surface. One borehole has been placed in each of the squares. From [2]

[1] Due to the highly inhomogeneous distribution, the value of the average may vary according to the way it is calculated.

Some radon measurements on and around the D1 dump have also been performed. Results are reproduced on Fig. 3.

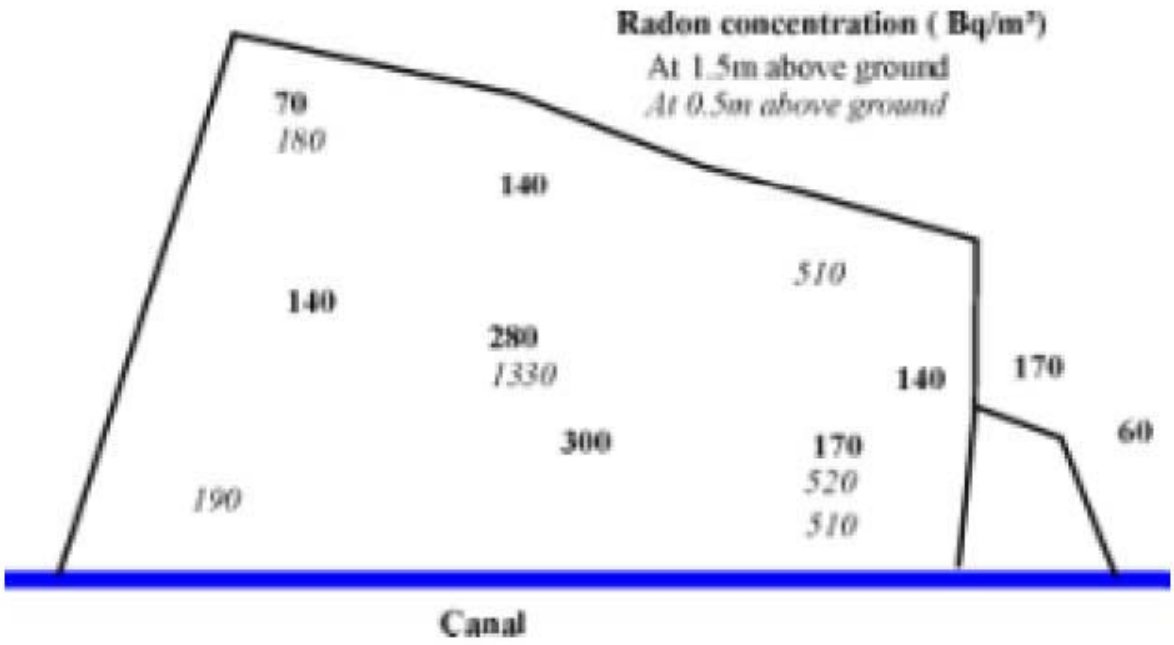

Fig. 3: Annual average concentration of Rn-222 in the air above the D1 dump at 1.5 m and 0.5m [3]

2.2.2 S1 dump

Dose rate measurements have been performed in boreholes showing that contaminated material is present essentially in a band at 6-8m depth (8-10m above the surrounding ground level) in the eastern part of the deposit.
The average value of Ra-226 activity concentration in this contaminated band has been evaluated to ~ 10 Bq/g (1 Bq/g if averaged over the whole volume of the deposit).

In some samples, activity concentration of U-238 has been measured up to 2 Bq/g (and 2.6 Bq/g for Th-230). Activity concentration of these two nuclides in the other samples is much lower.

3. Site data

3.1 Surface waters + (hydro-)geology

A good description of surface waters and hydrogeology may be found in [1], pp. 115-125. In addition, this report contains also data over climate, demography, flora and fauna.

Geology: The most important geological substrate of the region is constituted by the Kasterlee formation, a tertiary formation (Lower Pliocene) which is approximately 10 m thick at the site considered. It is constituted by clayey fine sands, micaceous and slightly glauconitic with some purple clay horizons. The lower portion of the formation is enriched in silt and clay minerals.

The water table of the **aquifer** lies between one and two meters beneath ground level. Groundwater flows in the direction of the river “Kleine Nete” located ~ 850m North of the D1 dump. The flow rate of the Kleine Nete is ~ 9000 m^3/h.

3.2 Climate

See p. 125 of [1] for data about average temperature and precipitations in the area.

3.3 Transfer factors to agricultural products and diet of critical group

Soil-plant concentration factors have been measured around the site. Results are given in Table I-VI of [1] (p. 130). This table is reproduced below:

TABLE I-VI. SOIL-PLANT CONCENTRATION FACTORS $\left(\frac{Bq/g\,DW}{Bq/g\,DW}\right)$ [a]

		Way of Contamination		
		Experimental Field		Greenhouse
		Concentration Factors (1961–1963)	Concentrations (Bq/g DW) (1963)	Concentration Factors
Ray–grass: overground parts		0.02–0.19	<0.37–13.4	0.41–0.75
Clover: overground parts		0.08–0.44	<0.4–1.3	≠0.07–0.50
Barley	– straw	0.01–0.15	0.55–1.2	0.10–0.90
	– ears	0.005–0.03	<0.14–0.50	0.05–0.09
Cabbage	– stem	0.02–0.99	– (0.44)	0.08–0.37
	– leaves	0.03–1.0	<0.15–1.5	0.06–0.81
Carrots	– roots	0.07–0.10	<0.09–2.5	0.26–0.54
	– overground parts	0.08–0.10	<0.54–7.4	0.12–1.15
Beet	– roots	0.04–0.05	<0.07–0.83	0.19–0.74
	– overground parts	0.03–0.16	<0.12–<2.6	0.50–1.51
Peas	– pods			3.1
	– leaves			0.6
Potatoes	– tubers	0.011–0.038	?	0.017–0.06

[a] Before sowing, the soil was ploughed (ploughing depth = 25 cm)

The diet of the critical group (cultivator families settling on site) is as follows:

TABLE I-VIII: ANNUAL CONSUMPTION - CRITICAL GROUP (kg/y)

Milk	131
Cheese	5.8
Meat	53.7
Poultry	8.2
Fish	5
Vegetables	56
Fruit	56
Potatoes	122
Eggs	18
Flour (wheat)	81
Water (well)	265

4. Radiological assessment

As mentioned in §1, part of this site has been assessed in the framework of the BIOMASS program (but the assessment didn't include D1 and S1 dumps) [1].
The assessment was performed with the following models (for a detailed description of the models, see appendix II of [1]): CLRP / CLRP-RAD, DOSDIM, OLENRAD, RISKOLEN, TAMDYN/TAMDYN-UV, RESRAD-ONSITE, RESRAD-OFFSITE.

The value of the parameters used in that assessment may be found in Section I.6.3 of [1] (pp. 157 – 162).

A dose-assessment for the D1 dumpsite has been performed in [4]: it included a normal evolution scenario (no major changes in the use of the dumpsite and of the surrounding areas) and two intrusion scenarios (construction scenario on site, person in a house built on site).

The normal evolution scenario led to a dose of ~2 mSv/y (almost completely due to radon). For the intrusion scenario (living in a house built on site), the dose was evaluated to 56 mSv (with radon again the dominant contribution: 44 mSv/y, external radiation: 6.5 mSv/y, consumption of vegetables grown on site: 5 mSv).
The dose was also evaluated for different remediation options.

5. References

[1] "Testing of environmental transfer models using data from the remediation of a radium extraction site", Report of the Remediation Assessment Working Group of BIOMASS Theme 2, IAEA, March 2004. *May be downloaded from:*
http://www-pub.iaea.org/MTCD/publications/PDF/Biomass7_web.pdf
[2] "Inventarisatie van de radiumbesmetting van de D1 stortplaats", M. Loos, H. Vanmarcke, E. Vangelder, SCK-CEN, March 1994 (in Dutch).
[3] "The Olen radium facility: Environmental contamination, impact on the population and site remediation", Proc. of 7th workshop on decommissioning of installations and site remediation, Arnhem, The Netherlands, October 2003.
[4] "Sanering van de omgevingsbesmetting met radium-226 te Olen en Geel", H. Vanmarcke, SCK-CEN, June 1997 (in Dutch).