NORM monitoring of landfills and brownfields

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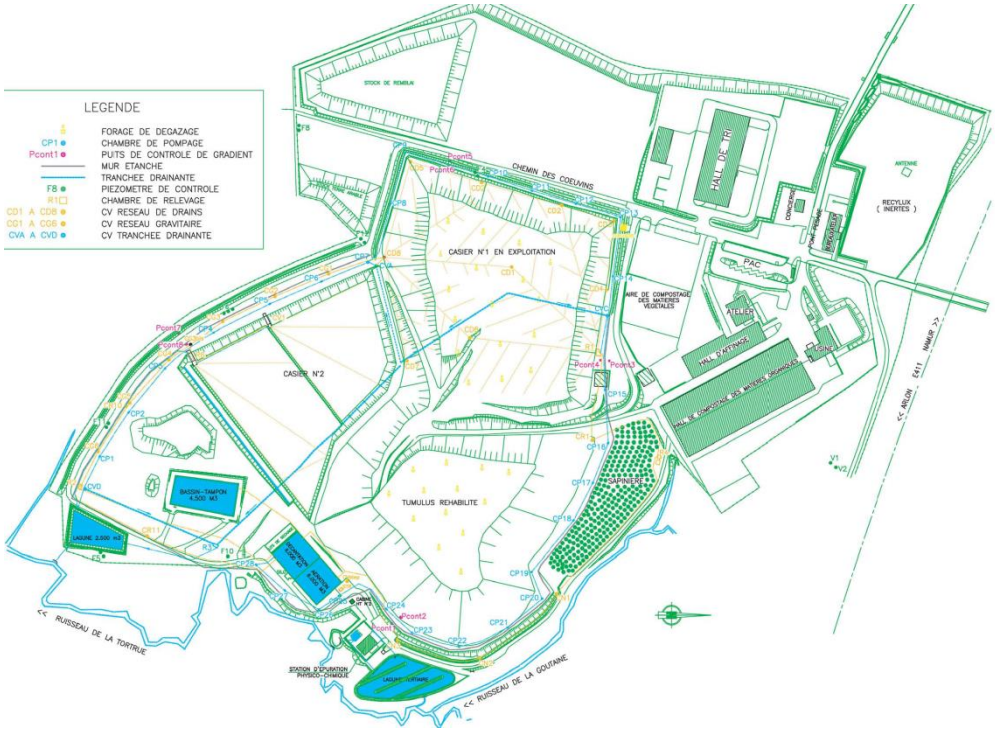
Overview

1) Introduction
2) NORM residues and NORM industries in Belgium
3) Experiences from portal monitors detections
4) measurement campaign around landfills
5) Landfills in operation: results groundwater
6) Landfills in operation: results leachates
7) Landfills in operation: results discharge and surface water
8) Comparison with NORM disposal sites or NORM legacy sites
9) Conclusions

Introduction

Landfills regulated according to EU “landfills” directive 1999/31/CE

- Landfill for hazardous waste;
- Landfil for non-hazardous waste;
- Landfill for inert waste;



- Waste acceptance criteria and procedure
- Water control and leachate management
- Protection of soil and water (geological barrier, bottom sealing)
- Divided in cells
- Environmental monitoring

Why care about NORM on landfills ?

In the past, landfills not properly regulated ⇨ environmental impact

Disposal of NORM regulated only recently (Belgium from 2013)

Exemption/clearance values

If AC > clearance
⇒ NORM disposed by registered operator

Radionuclide	Activity concentration (Bq/g)
U-238sec (incl. U-235sec)	0.5
	0.1 (mono-landfill)
U nat	5
Th-230	10
Ra-226+	0.5
	0.1 (mono-landfill)
Pb-210+	5
Po-210	5
Th-232sec	0.5
	0.1 (mono-landfill)
Th-232	5
Ra-228+	1
Th-228+	0.5
K-40	5

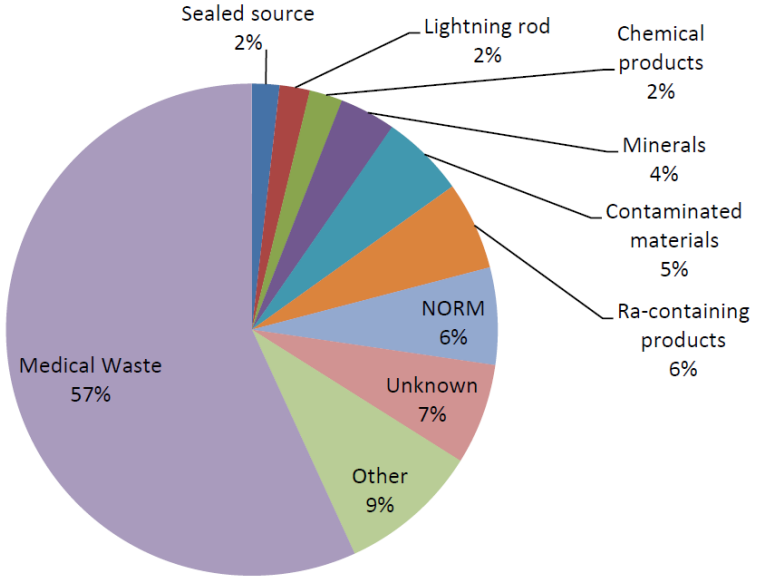
What about NORM landfilled in the past ?

Experience from portal monitors detection

Belgium, most of waste treatement or recycling installations equiped with portal monitors

2012 – 2017:
1659 detections

Installations	# detections
Scrap yards	256
Metal industry	120
Recycling park	9
Sorting centres	131
Landfills	**28**
Incinerators	940
Bio-mechanical processing	128
Customs	47



Any impact of small radioactive sources disposed in the past ?

NORM monitoring of landfills

All landfills have some inventory of NORM

Screening **landfills** since 2012:
- 10 landfills for non-hazardous waste (not registered for NORM)
- 3 landfills for hazardous waste (registered for NORM)
- 5 old municipal landfills

Measurements in **leachate, discharge water, surface water, groundwater**

Gross alpha, gross beta, K-40 + U, Ra-226

First campaign **2012** (leachates):

⇒ No reference levels (= discharge limits) exceeded but some non trivial values (e.g. 1.2 Bq/l Ra-228 in leachate)

Landfills in operation : groundwater

2012 – 2016:

Groundwater landfills non-hazardous waste: 33 samples
Gross alpha, gross beta measurements (compared to screening values drinking water regulations: 0.1 Bq/l – 1 Bq/l)

$\Rightarrow$ 5 > screening (α_{tot} max. 0.15) – no significant difference compared to background values

Groundwater landfills hazardous waste (+ NORM):
16 samples : α_{tot} < 0.1 Bq/l

Groundwater landfill for residues manganese production
[Ra-226] ~ 0.15 Bq/l – [U] ~ 9 µg/l – Beta total ~ 1.09 Bq/l

Landfill for residues steel industry α_{tot} < 0.1 Bq/l both for GW, drainage and discharge water

Landfills in operation: leachates

Leachates:

	landfills for non-hazardous waste				landfills for hazardous waste			
	#measurements	range	average	median	#measurements	range	average	median
U (µg/l)	27	0.1 - 46	4.8	1	9	0.1 – 1.9	0.57	0.38
Ra-226 (mBq/l)	22	2 - 216	47	20	9	8 - 210	98	112
Pb-210 (mBq/l)	5	9 - 50	21	15	3	10-12	11	
Po-210 (mBq/l)	4	5 - 33	13		6	1-18	5	3
Ra-228 (mBq/l)	4	30 – 1220	720					

Leachate: high concentration in salts => potassium up to ~**8**g/l

⇒ Gross beta upto 211 Bq/l

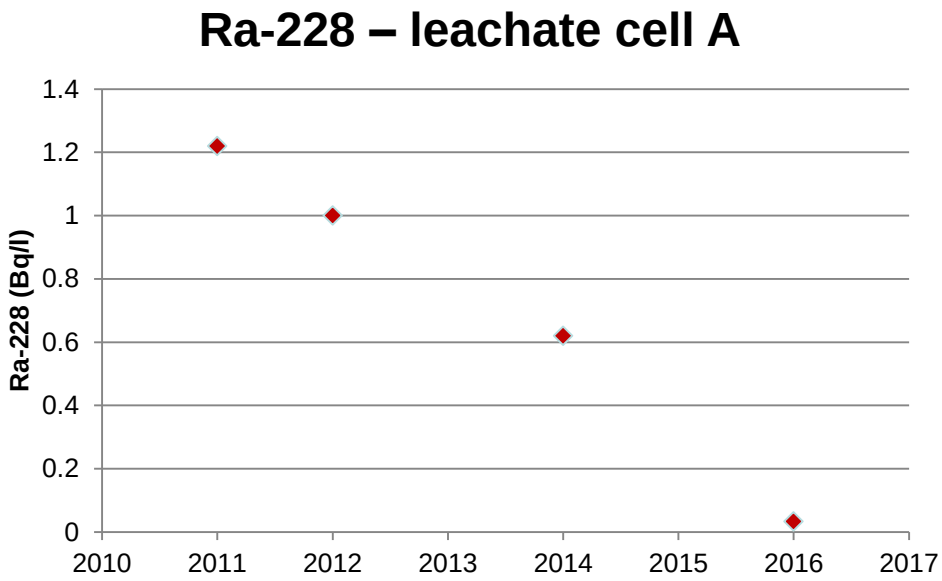
⇒ Self absorption alpha signal : high detection limit for gross alpha

Leachate -

Leachate landfill non-hazardous waste

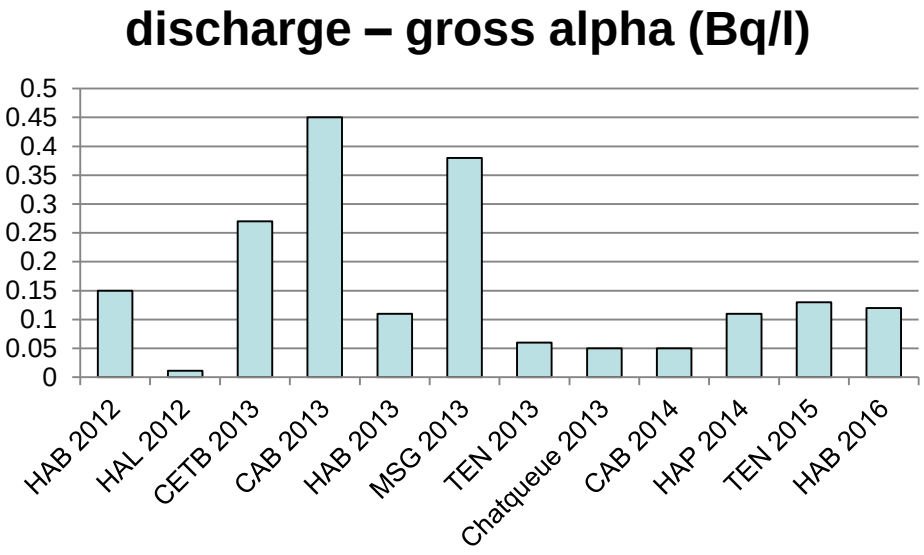
2011: first measurement : [Ra-228] in leachate of one cell close to discharge limit

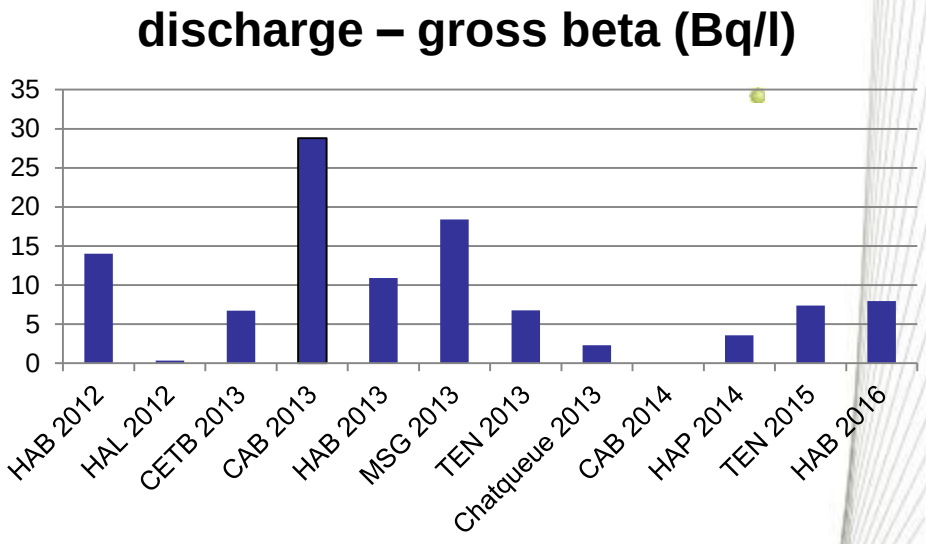
⇒ Follow-up : Ra-228 back to trivial values in 2016



Landfills – discharge water

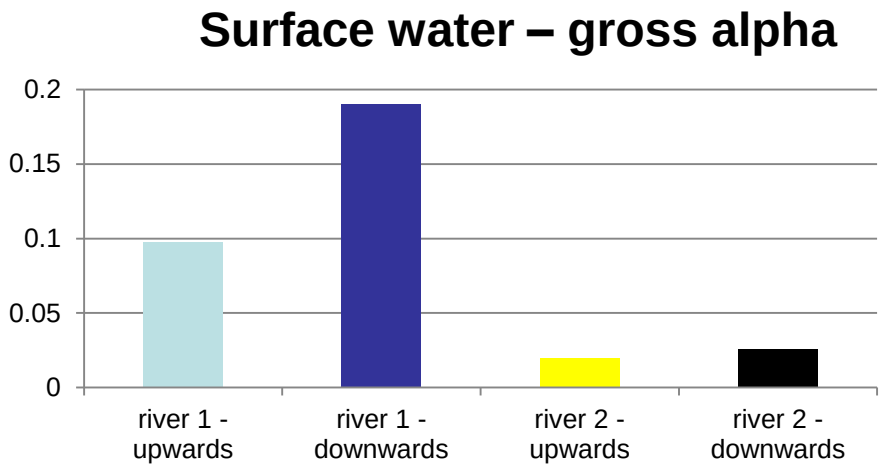
Measurements on discharge water (after treatment of leachates)
13 samples - K-40 (salts), sometimes Ra-226 and U

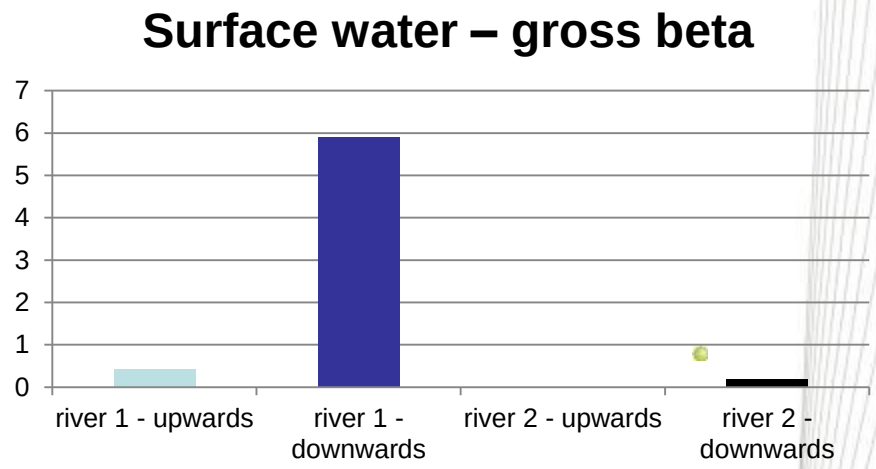


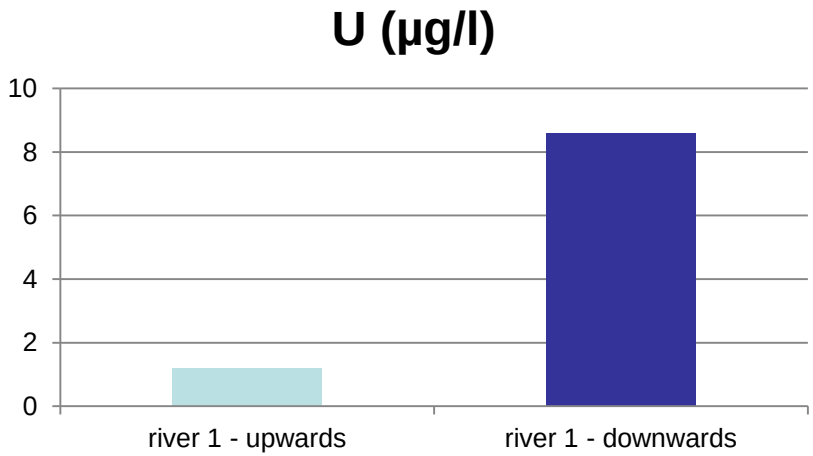


Landfills – surface water

4 samples in discharge river (stream upwards/downwards discharge point)
=> for one landfill – more potassium and uranium after discharge point

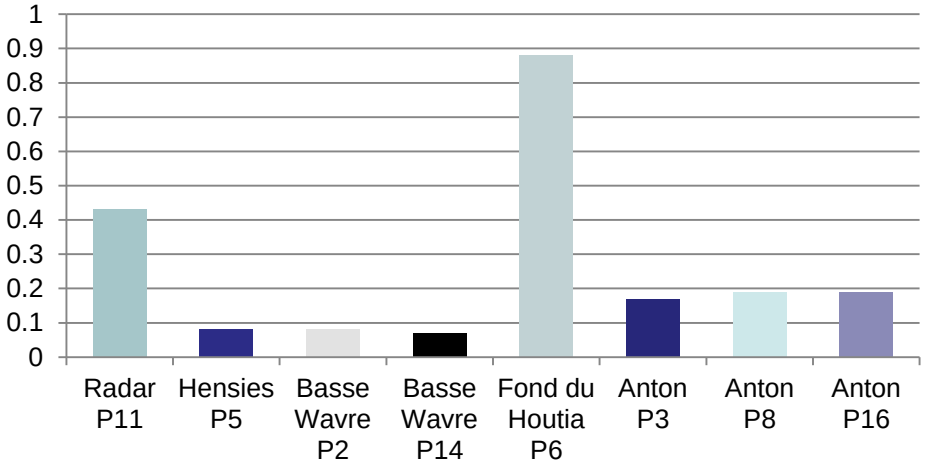




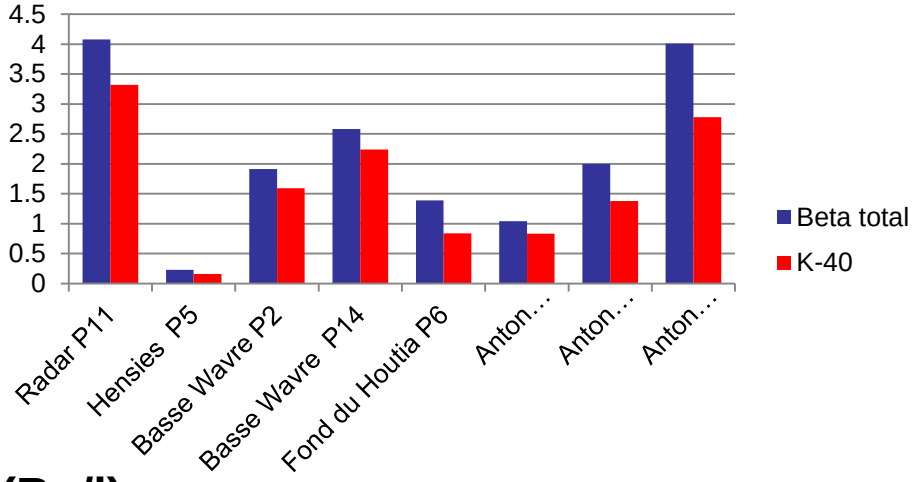


Groundwater: old landfills

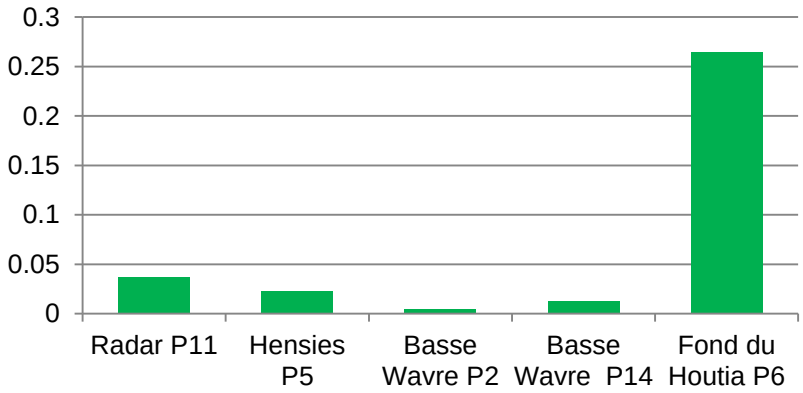
Gross alpha (Bq/l)



Gross beta total / K-40 (Bq/l)



Ra-226 (Bq/l)



⇒ For two old landiffls : non trivial values U (U = 20 µg/l + 15 µg/l)

⇒ One landfill (“Fond du Houtia”) Ra-226 = 0.25 Bq/l

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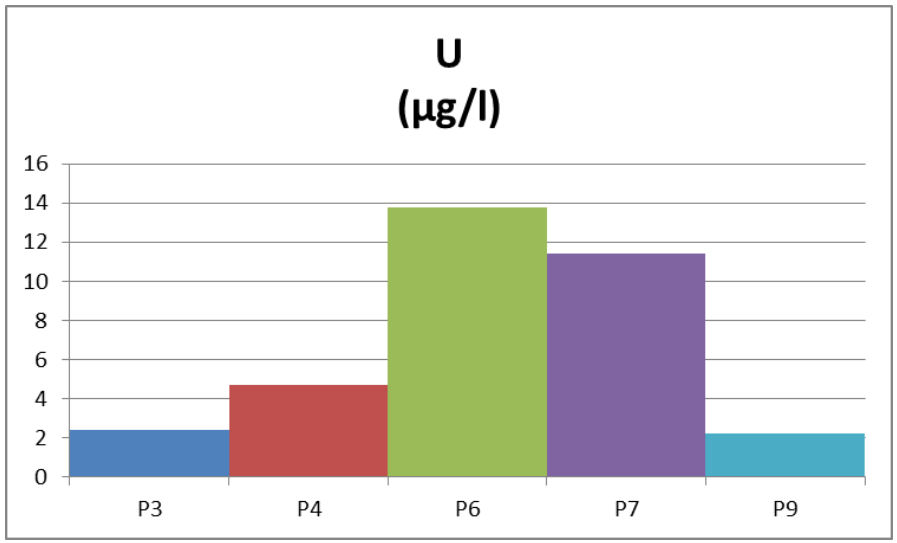
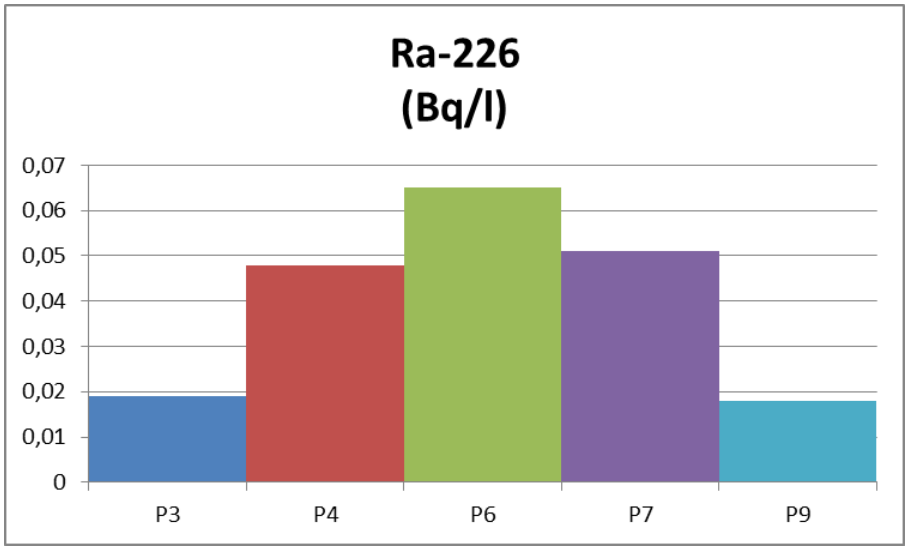
Groundwater: old landfills

- “Fond du Houtia”: used as municipal landfill between 1973 and 1983 + illegal dumping until 1989
- Remediated in 2003 – environmental monitoring
- 2017: new measurements on all wells along the old landfill



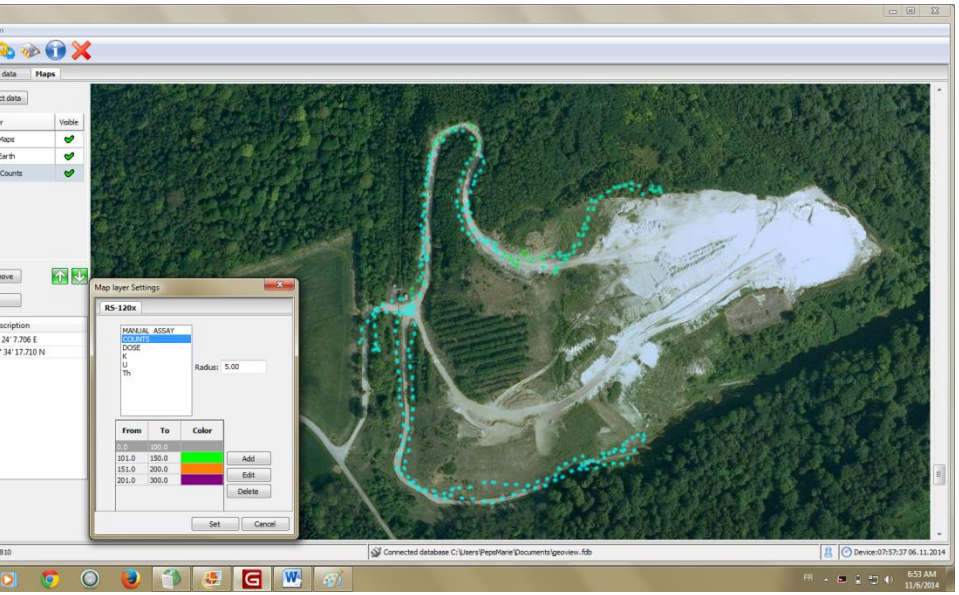


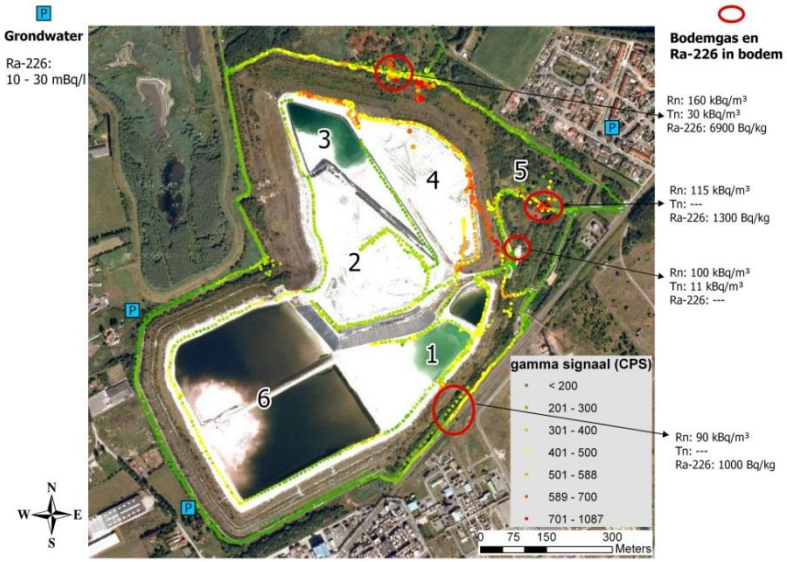
“Peak” of contamination in well P6 (also for other heavy metals + chloride)

Monitoring NORM sites – phosphogypsum stack

Two PG stacks:

1) Disposal PG after neutralization (in operation)
2) Disposal PG disposed in acidic conditions (bankruptcy of operator in 2009)





Monitoring NORM sites – phosphogypsum stack

PG stack 1 (PG neutralized)

Ra-226 in GW and drainage water followed since 2000

⇒ *Trivial values* (max. 40 mBq/l)

2016: gross alpha max. 0.16 Bq/l

PG stack 2 (acidic conditions)

"Historical" leachate (old part of stack)

"historical" leachate	Gross alpha (Bq/l)	Gross beta (Bq/l)
2017	5.7	5.2
2015	8.5	5.3
2014	6.3	6.3

"historical" leachate	
U (µg/l)	500
Ra-226 (mBq/l)	12
Po-210 (mBq/l)	260

GW (well BXF2)	
Gross α (Bq/l)	0.3
U (µg/l)	0.8
Ra-226 (mBq/l)	47
Pb-210 (mBq/l)	22
Po-210 (mBq/l)	52

Discharge water: gross alpha = 0.17 Bq/l

GW: max gross alpha = 0.3 Bq/l

GW monitoring NORM legacy site: ferro-niobium

Extraction of FeNb in 1960s – 1970s
⇒ slag with up to 60 Bq/g Th-232 and 12 Bq/g Ra-226
⇒ patchy contamination

	PM028				PM030				E404			E401		
	2011	2012	2014	2016	2011	2012	2014	2016	2011	2012	2014	2011	2012	2014
Gross α (Bq/l)	0.9	0.07	< 0.09	< 0.07	0.4	0.57	0.25	0.42	0.24	0.93	0.24	0.15	0.18	0.26
Gross β (Bq/l)		5.8	4.54	4.2		2.3	1.26	1.41		5.4	4.17		1.57	1.28
U (µg/l)				< 0.4			0.147	< 0.4			0.92			8.7
Ra-226 (Bq/l)				0.0197		**0.25**	**0.138**	**0.283**		0.043	0.024		0.016	0.0058
Ra-228 (Bq/l)								0.047						
K-40 (Bq/l)			4.725	3.7			0.726	1.37			4.217			1.203

Increased value of Ra-226 in well PMO30 => probably related to presence of *quick lime*

Uranium production

Main GW contamination observed on sites where U production took place

- radium extraction and production of radium sources in **Olen** (from 1922 to 1975): up to 730 µg/l U
- production of uranium salts in **Brussels** from ~1925 to 1943: likely related to U contamination in groundwater - up to 660 µg/l)
- Uranium production from **phosphate** minerals : U up to 136 µg/l (may be related to phosphoric acid plume)

Conclusions

Landfills in operation:

- For some landfills, observable impact on **leachate** or **surface water** (U, Ra-228)
- No reference values exceeded => **no issue from radiation protection**
- No noticeable impact on **groundwater**
- No difference between “ordinary” landfills and landfills (for hazardous waste) authorized for disposal of small quantities of NORM

Old landfills (no bottom liner, no collection of leachates)

- GW may be locally impacted (U, Ra-226)

⇒ see also U measurements around some old landfills in the Netherlands (Oosterhout – Gilze en Rijen upto 178 µg/l)

Conclusions (2)

- With the exception of U production, impact of **NORM disposal sites** **on groundwater** not significantly different from “ordinary” landfills …

- Physico-chemical conditions as much important as NORM inventory of landfill

- groundwater: more impact on facilities site (U contamination) than on disposal sites

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