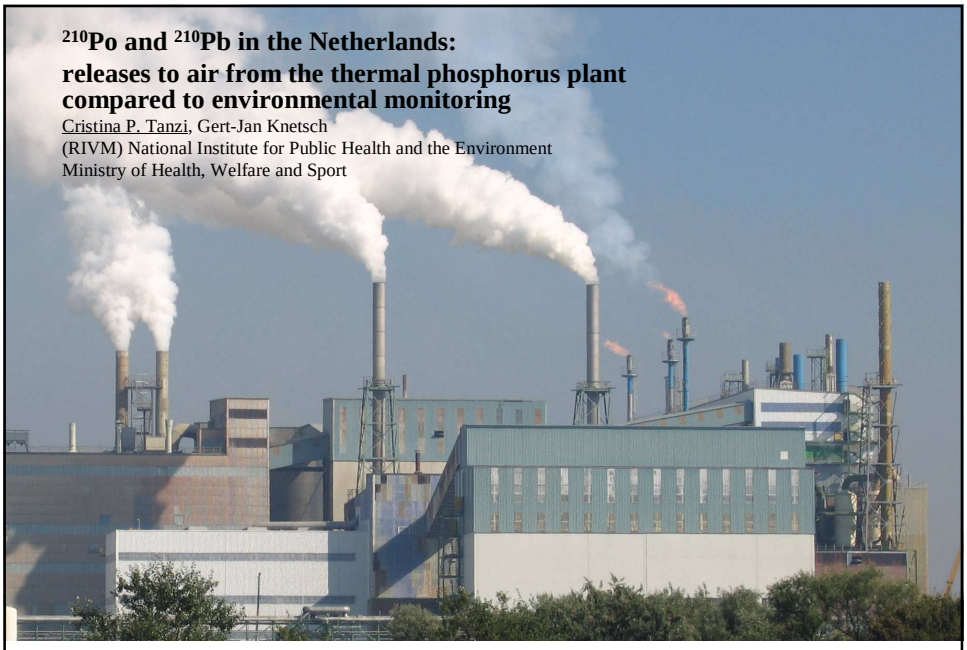
^{210}Po and ^{210}Pb in the Netherlands: releases to air from the thermal phosphorus plant compared to environmental monitoring

Cristina P. Tanzi, Gert-Jan Knetsch
(RIVM) National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport



Thermal Phosphorus plant, Vlissingen, NL

Tallinn, 06 June 2012

Overview

- RIVM (NL Institute for Public Health and the Environment): Po-210 and Pb-210 measurements (EURATOM)
- The only thermal phosphorus plant in Europe: NORM to air
- NORM emissions of the same order of natural background
- USE OF MODELLING (air dispersion
  + IAEA dose estimate for regulatory purposes)
- ASSESSMENT OF DOSE TO GENERAL PUBLIC:
  - dose from actual emssions < permit
  - plant permitted limit 40 μSv/y
  - about ¼ of Po-210 and Pb-210 background with same model

the Netherlands

RIVM

Thermal

phosphorus

plant

Environmental measurements: RIVM (Utrecht)

High Volume Sampler: from 1990 to 2011

4 filter units (glass fiber 18x23 cm^2)

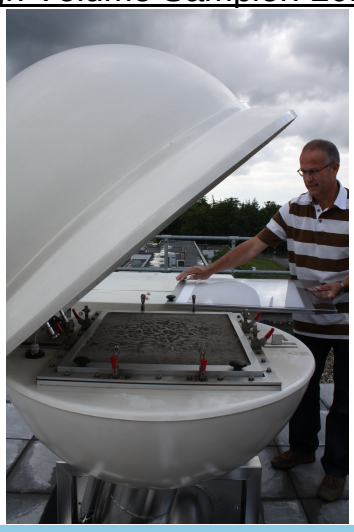
50000 m^3/week

Environmental measurements: from 1990 to 2011

High Volume Sampler: 2011 onwards

125000 m^3/week – filter type G3 (polypropylene) 57x46 cm^2
Efficiency 96±1% for Pb-210 and Be-7

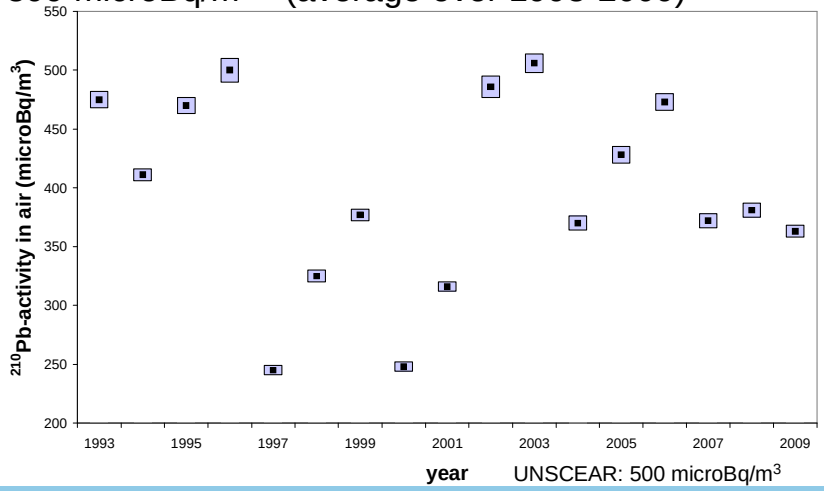
High Volume Sampler: 2011 onwards



Pb-210 activity in air

γ-spectrometry on 50000 m^3/week HPGe-detector

399 microBq/m^3 (average over 1993-2009)



UNSCEAR: 500 microBq/m^3

Environmental measurements: RIVM (Utrecht)

deposition:

Weekly:
Pb-210 (γ-spectrometry)

Monthly (1 to 20L volume):
Po-210
+100 ml HCl (6 mol/L) carrier

Deposition: Po-210 analysis

Rinse with 1L demineralised water

Po-208 or Po-209 tracer solution added

Evaporate to 100 mL on cooking plate

Reduce to residue on water bath

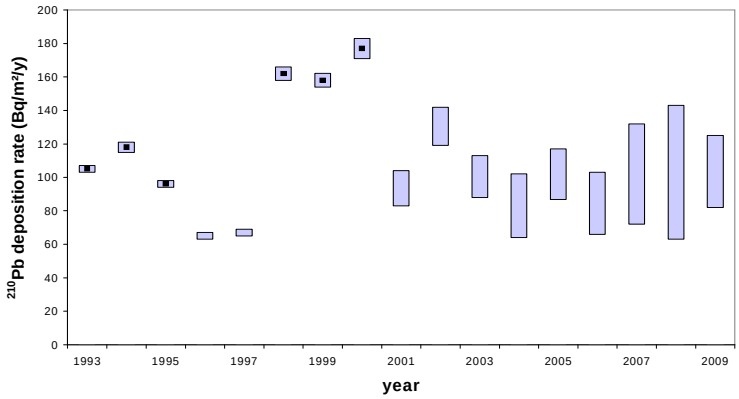
Dissolve in HCl (6 mol/L)

Add $NH_2OH.HCl$ and adjust to pH 1,5

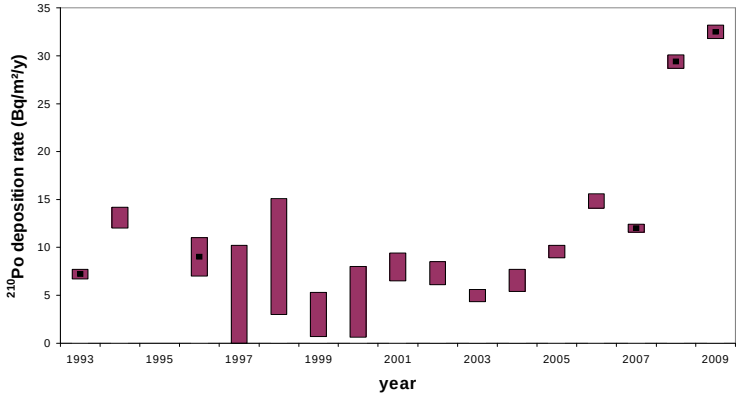
Auto-electrodeposition on silver disk at 90°C for 4h

α-spectrometry

Yearly Pb-210 activity deposited in Bilthoven, NL
60 to 180 Bq/m^2/y
bar: 2σ
no dot if at least one weekly measurement <= DL



Yearly Po-210 activity deposited in Bilthoven, NL
0 to 33 Bq/m^2/y
bar: 2σ
no dot if at least one monthly measurement <= DL



Thermal elemental phosphorus plants

MONSANTO: USA (Idaho, Soda Springs)

Kazakhstan (Kazphosphate)

India

China? (small operators?)

Europe

The only **thermal** phosphorus plant in Europe

1963: NL Nuclear Energy Act

1973: NPP on river estuary

1983: NPP monitoring shows Po-210 > background

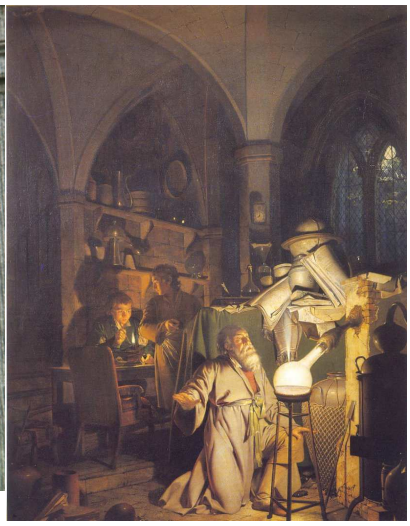
CAUSE IDENTIFIED:
Hoechst (now Thermphos)

1985: operating permit granted

1987: plant reports emissions

the granted emission limits are based on dose assessment to the public

Phosphorus production in the past



H. Brand, 1669

The Alchymist in Search of the Philosophers' Stone discovers Phosphorus

Credit: Joseph Wright of Derby, 1771

15

see García-Tenorio, these proceedings, p. 202

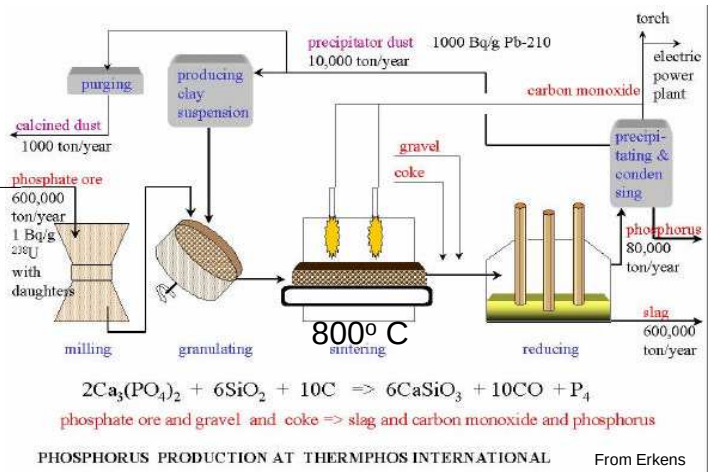
Phosphorus production now (thermal)

OCP (NORM VI)

phosphate ore:

apatite

$Ca_5(PO_4)_3(F/OH)$



From Erkens

- slag: incidental release to ground
- sintering: continuous release to air of Po-210, Pb-210, Cd, Pb, Zn, Cu, Cr, Hg, dioxine

Only **thermal** phosphorus plant in Europe

450 employees (in NL)

- **Elemental phosphorus (sintering)**
- Phosphoric acid and phosphate (wet process): DAP, MAP
- NTTP (sodiumtripolyphosphate)

+ Marketing and sales

1997: independent within Hoecsht

2000: independent

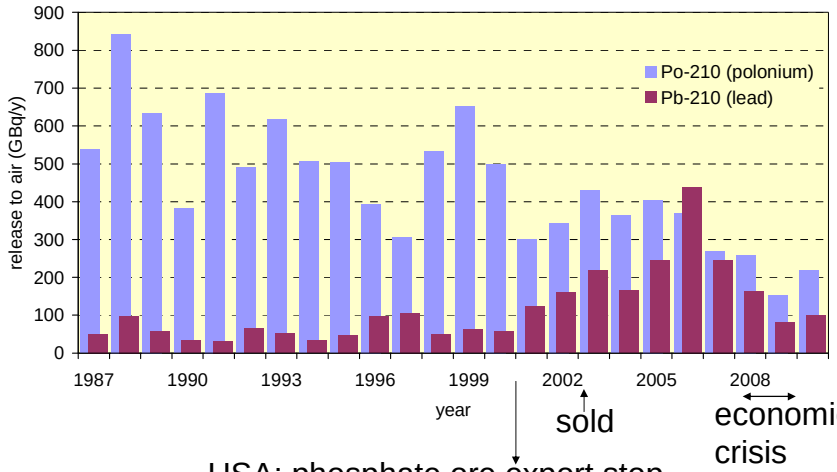
2003: acquired by (the same group which owns) Kazphosphate

DAP, MAP: diammomnium, monoammnium phosphate

Thermphos phosphorus products (list from 1997)

kton	product	use
53	P_4	export to industries producing all of the following:
42	NTPP	detergents
18	H_3PO_4	foodstuff + acid pickling baths (part returns to wet process)
0,4	PCl_5	pharmaceutical products
1,4	$POCl_3$	plastics (plasticiser, stabiliser, flame retardant)
3,2	PCl_3	pesticide (mainly)
2,0	P_2S_5	(car) industry (lubricant, pneumatic oil)
0,8	FeP	additive to steel
120	Total	

Po-210, Pb-210 emissions to air



sold

economic crisis

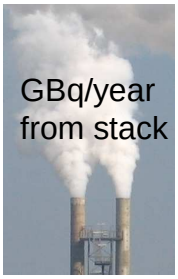
USA: phosphate ore export stop (stop of Florida ore)

Phosphorus production in the future of Thermphos

from secundary fosfor sources (not ores but return streams – e.g. manure from water purification)

2010	15%
horizon 2020	100%

Model of environmental concentration, from reported emissions to air

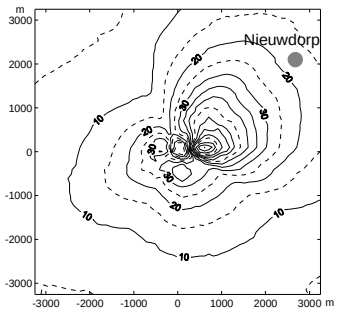


AMAD < 0.5 µm

air dispersion model (OPS)

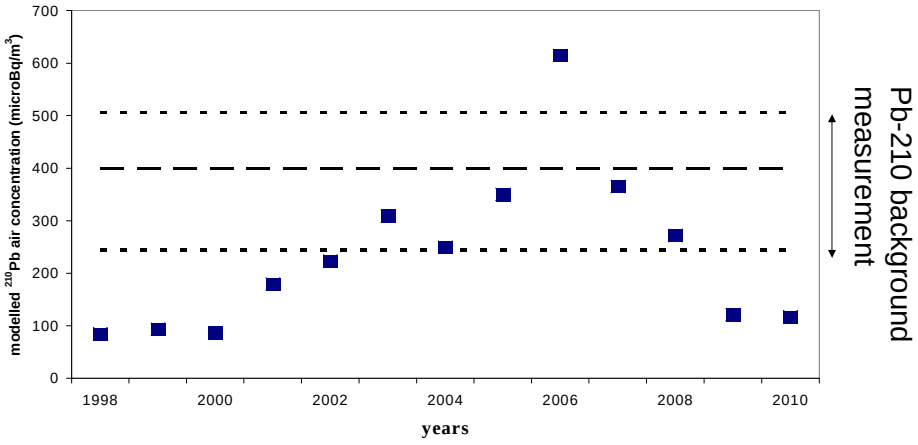
air concentration

ground deposition rate



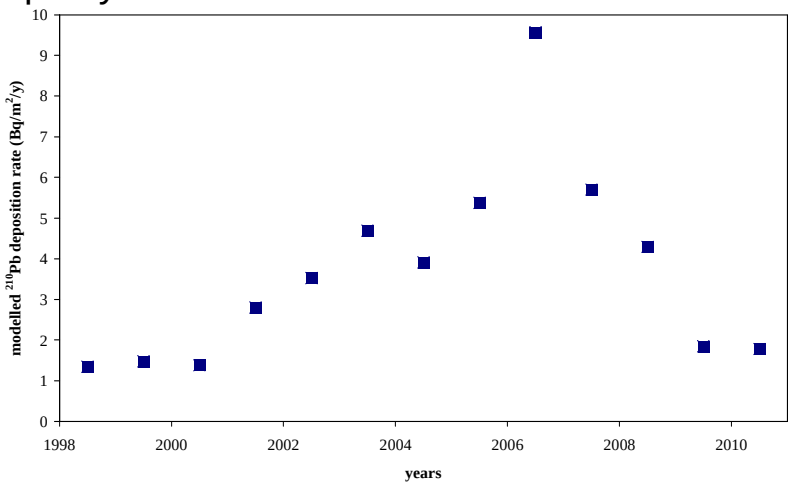
air dispersion model (OPS) at Nieuwdorp village, 4 km downwind

microBq/m^3



air dispersion model (OPS) at Nieuwdorp village, 4 km downwind

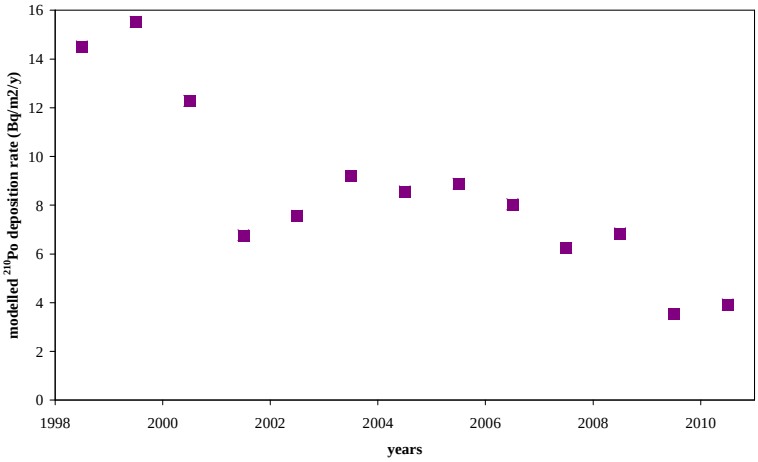
Bq/m^2/y Pb-210



negligible compared to 60 - 180 Bq/m^2/y background level

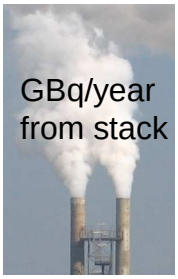
air dispersion model (OPS) at Nieuwdorp village, 4 km downwind

Bq/m^2/y Po-210



compare to 0 - 33 Bq/m^2/y background level

Assessment of effective dose from reported emissions to air



AMAD < 0.5 µm

air dispersion model (OPS)

air concentration → inhalation

ground deposition rate

→ingestion pathway

follows IAEA SRS No. 19, 2001

emission constant over 25 y

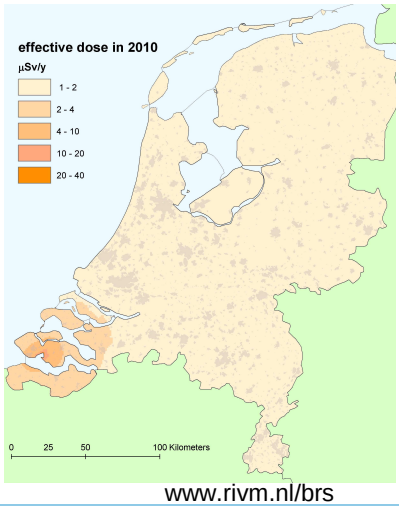
food basket:
grain, potatoes, meat, milk, leafy vegetables, + FRUIT

+ full ingrowth calculation

Ingestion dose

	potatoes	cereals	fruit	veg	milk	meat	total
Yearly consumption (kg)	51	71	19	42	147	10	340
25 years plant operations							
Pb-210: 500 GBq/y							
Effective dose (microSv/y)	0.7	0.3	0.6	0.7	<0.1	<0.1	2.3
Po-210: 500 GBq/y							
Effective dose (microSv/y)	0.3	0.2	0.6	0.6	<0.1	<0.1	1.7
Natural background							
Pb-210 100 Bq/m^2/y							
Effective dose (microSv/y)							140
Po-210 10 Bq/m^2/y							
Effective dose (microSv/y)							7

Effective dose in NL

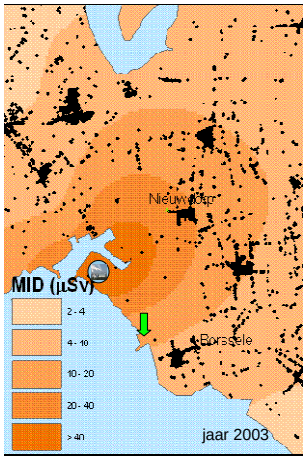


www.rivm.nl/brs

Permitted level phosphorus plant:

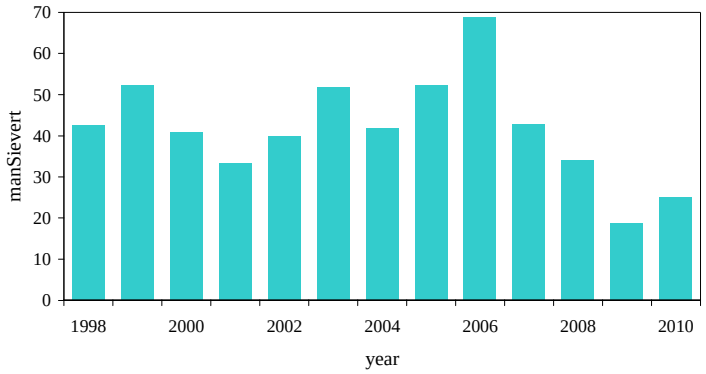
40 µSv/year at closest dwellings

Thermal phosphorus: effective dose from air emissions



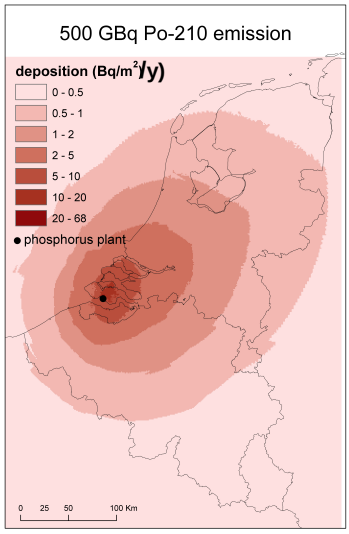
Collective dose: ∫ effective dose x inhabitants

Collective effective dose in NL from emissions to air in NL



the model predicts increased Po-210 and Pb-210 in Belgium

Thermal phosphorus: deposition rate in Belgium from NL air emissions



Summary

Thermal phosphorus plant emissions to air

Before 2000:

500 GBq Po-210
50 Gbq Pb-210

After 2000:

250 GBq Po-210
200 GBq Pb-210 (>400 GBq in 2006)

Model of environmental load comparable to background level

Dose assessment

1. reported emissions to air
2. air transport modelling
3. dose from inhalation, ingestion
   (food basket:
   grain, potatoes, vegetables, meat, milk, + FRUIT)

→ in 2010 < 40 microSv/y (permitted level)
collective dose: 30 manSv/year in the Netherlands