



Workshop European ALARA Network for NORM

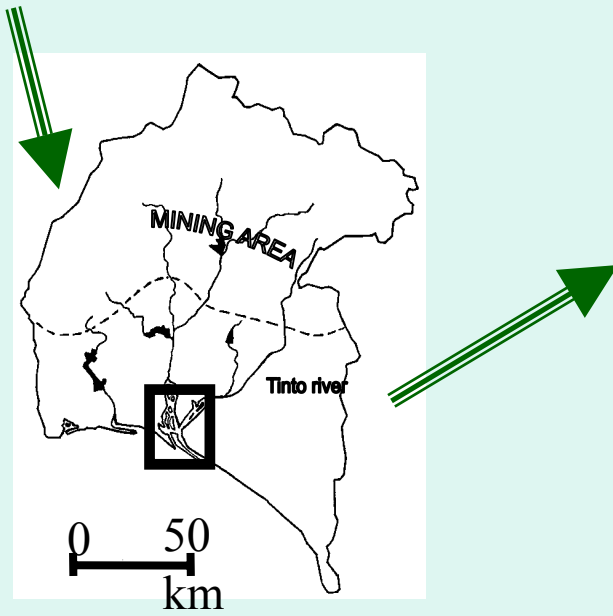
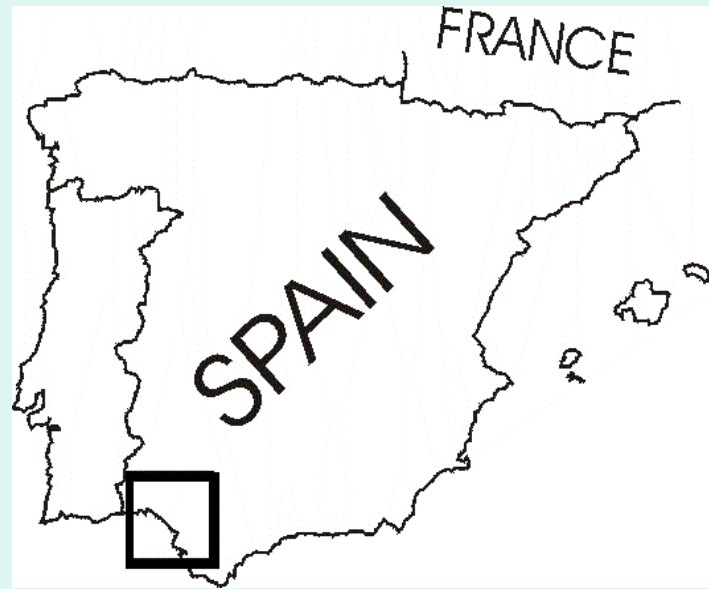
Dresden (Germany) 20th-22nd Novembre 2007

EXPERIENCES OF THE PHOSPHATE INDUSTRY DEALING WITH NORM IN SPAIN

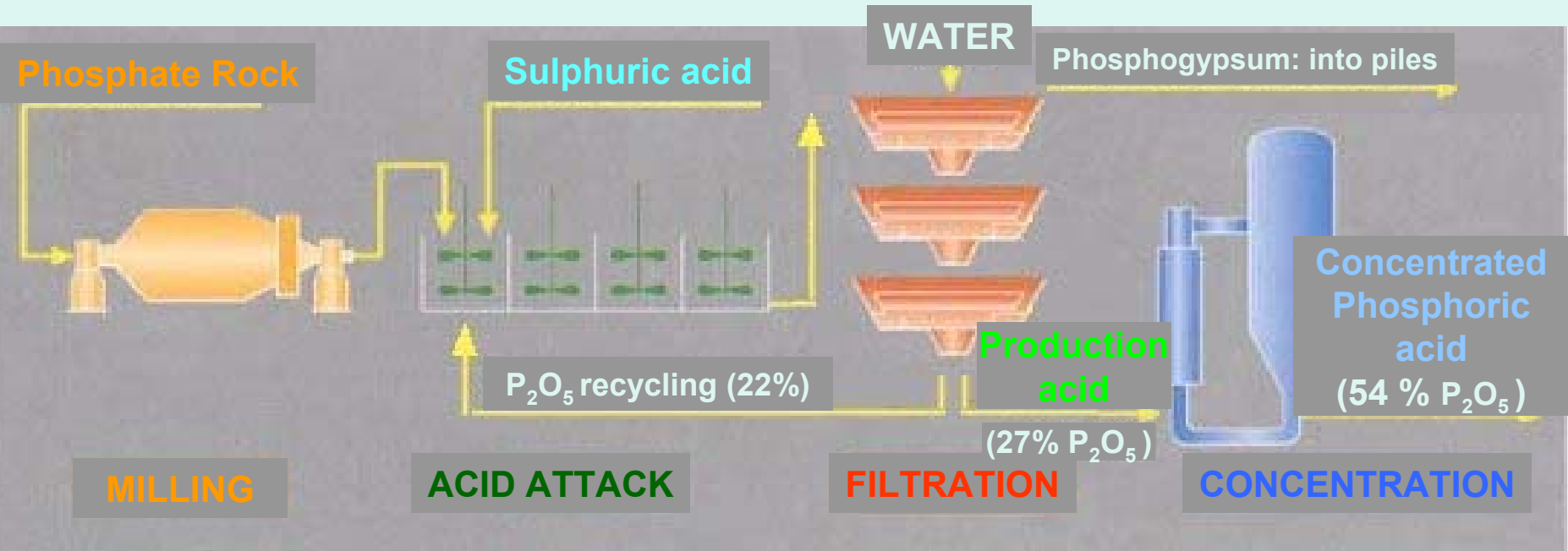
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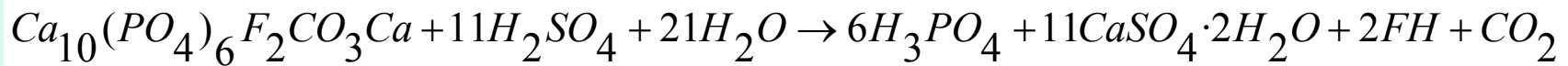
SPAIN







Phosphate rock + Sulphuric Acid ----- Phosphoric Acid + Phosphogypsum



ANNUAL CONSUMPTION - PRODUCTION



Phosphate Rock	~ 2·10 ⁶ Tm
Phosphoric Acid	~ 2·10 ⁶ Tm
Sulphuric Acid	~ 2·10 ⁶ Tm
Phosphogypsum	~ 3·10 ⁶ Tm

Sedimentary Phosphate Rock (PR)

$^{238}\text{U} \sim 1.5 \cdot 10^3 \text{ Bq/kg}$; $^{232}\text{Th} \sim 30 \text{ Bq/kg}$

Filtration step. Activity concentrations (Bq/kg)

Sample	^{238}U	^{226}Ra	^{228}Ra
PG before washing	810 ± 50	880 ± 40	14 ± 2
PG after first washing	460 ± 30	1040 ± 50	15 ± 2
PG after second washing	450 ± 30	1000 ± 50	17 ± 2
PG to be stored	280 ± 20	900 ± 50	14 ± 2
Optimum size PR	1630 ± 90	1780 ± 90	22 ± 2

Concentration step. Activity concentrations (Bq/kg)

Sample	^{238}U	^{226}Ra	^{228}Ra
P_2O_5 (32%)	1300 ± 70	4 ± 1	< 1
P_2O_5 (54%)	1830 ± 90	8 ± 1	< 1



Area 1

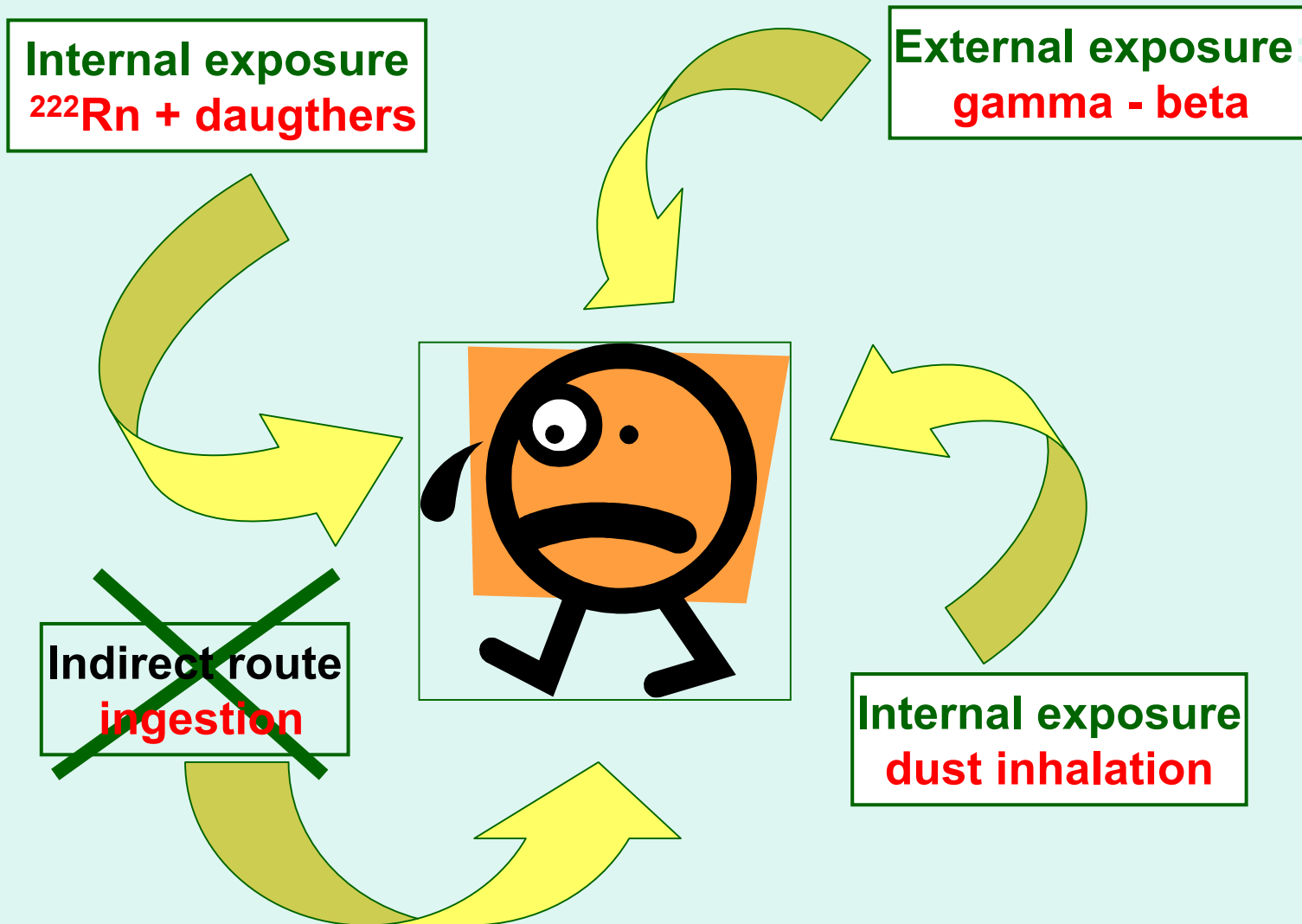
Area 2

Area 3

Area 4



Occupational exposures inside the Factory



EXTERNAL GAMMA DOSE RATES

$\Delta_{\text{external doses}} (\mu\text{Sv/h})$

Milling, n=10
0.03 – 0.37

Reaction, n=6
0 – 0.10

Filtration, n=11
0.10 – 1.36

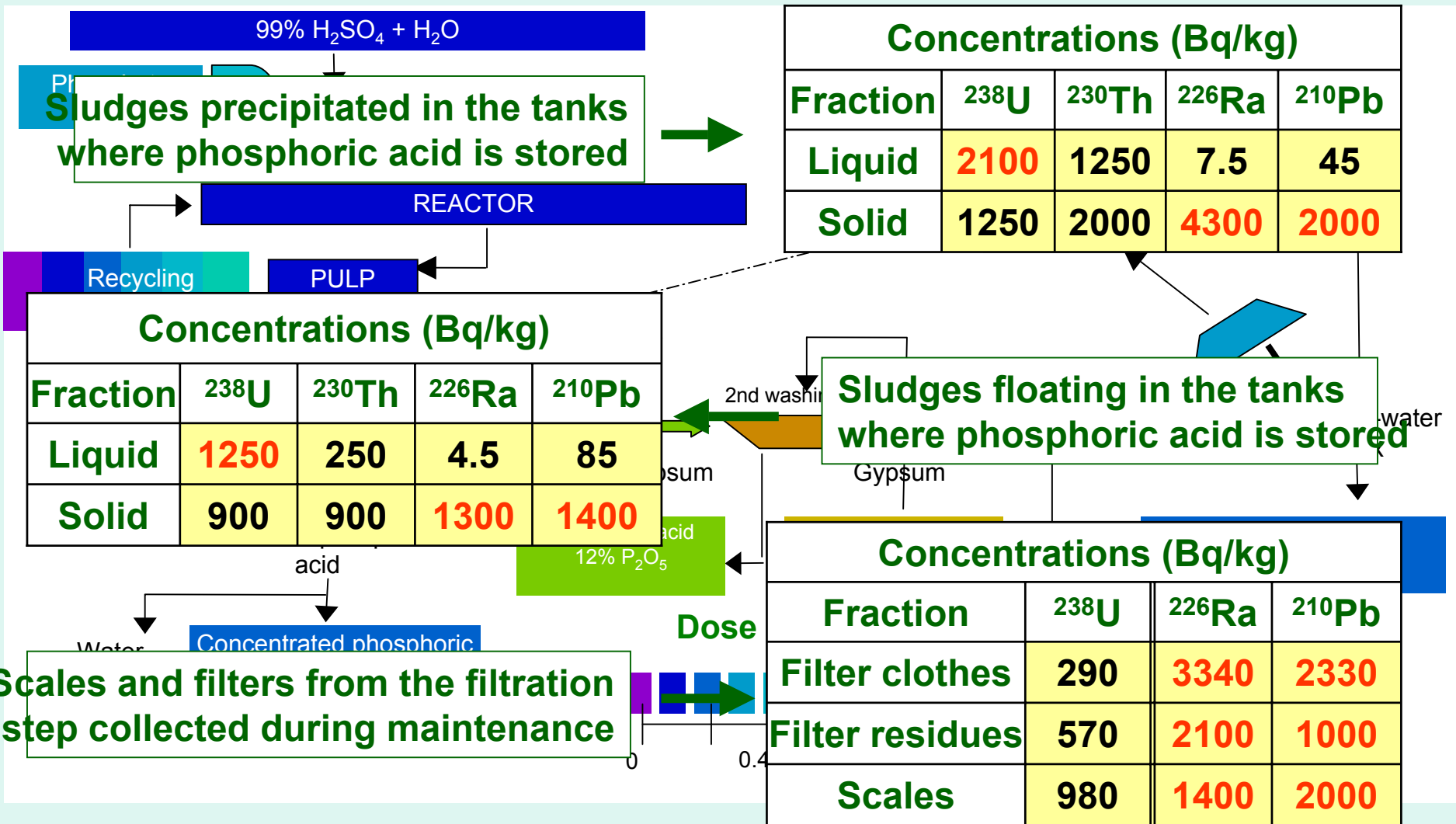
Decantation, n=7
0 – 0.50

Concentration, n=5
0.01 – 0.32

Worker rooms, n=5
~ 0

Factory entrance
Background

EXERCISES



EFFECTIVE DOSE RATES (I)

Effective external gamma dose rate (mSv/y)	Worker Type I	Worker Type II
Phosphate rock storage zone	0.015	---
Milling Zone	0.135	---
Digestión-Attack Zone	0.050	0.050
Filtration Zone (over the filters) (1)		0.105
Filtration Zone (around the filters) (2)		0.090
Concentration Zone		0.090
Common Zones (3)	0.007	0.007
TOTAL	0.207 mSv/año	0.342 mSv/año

(1) Region of the Filtration Zone practically not accessible to the workers. Occupational time consider for the worker Type II taken as very conservative.

(2) Region of the Filtration Zone accesible to the workers.

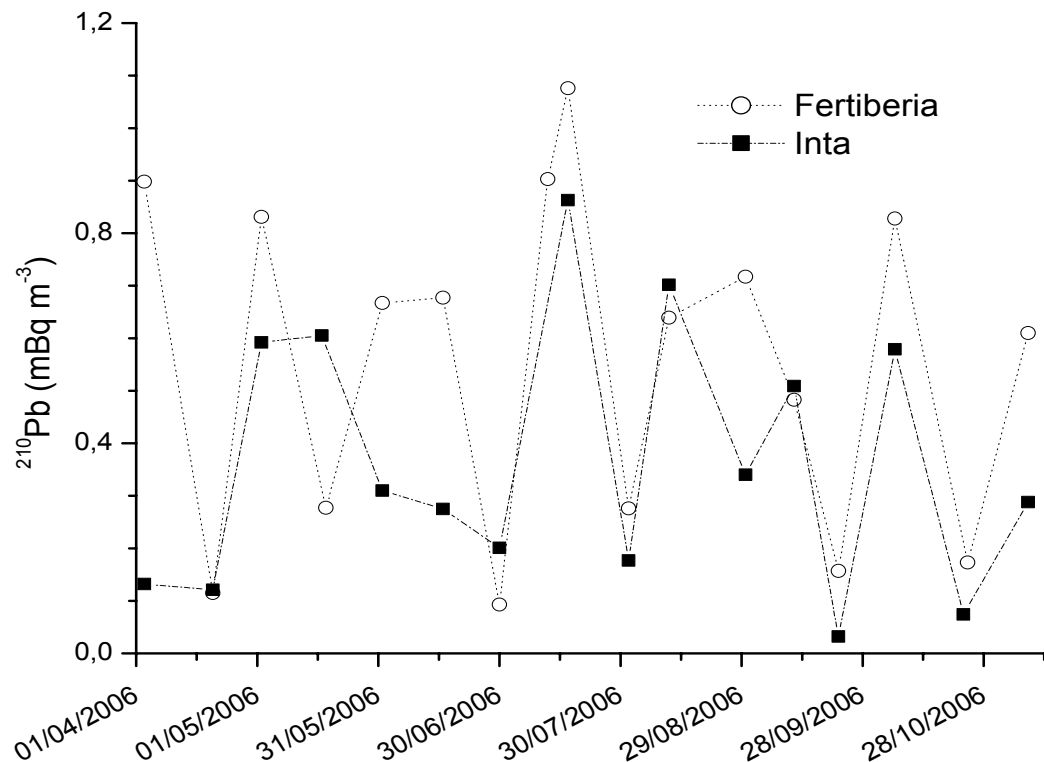
(3) Laboratories, Control rooms, Workshops, etc

EFFECTIVE DOSE RATES (II) INHALATION



Aerosol collectors in background area

$\Delta_{\text{inhalation dose}}$
< 0.20 mSv/y



RADON DETERMINATIONS IN THE FACTORY

Passive Measurements

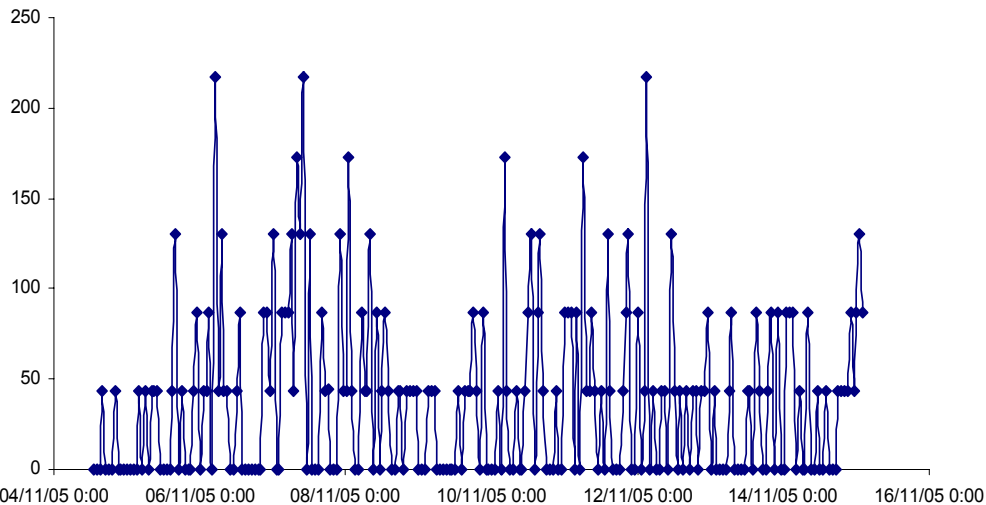


Active Measurements

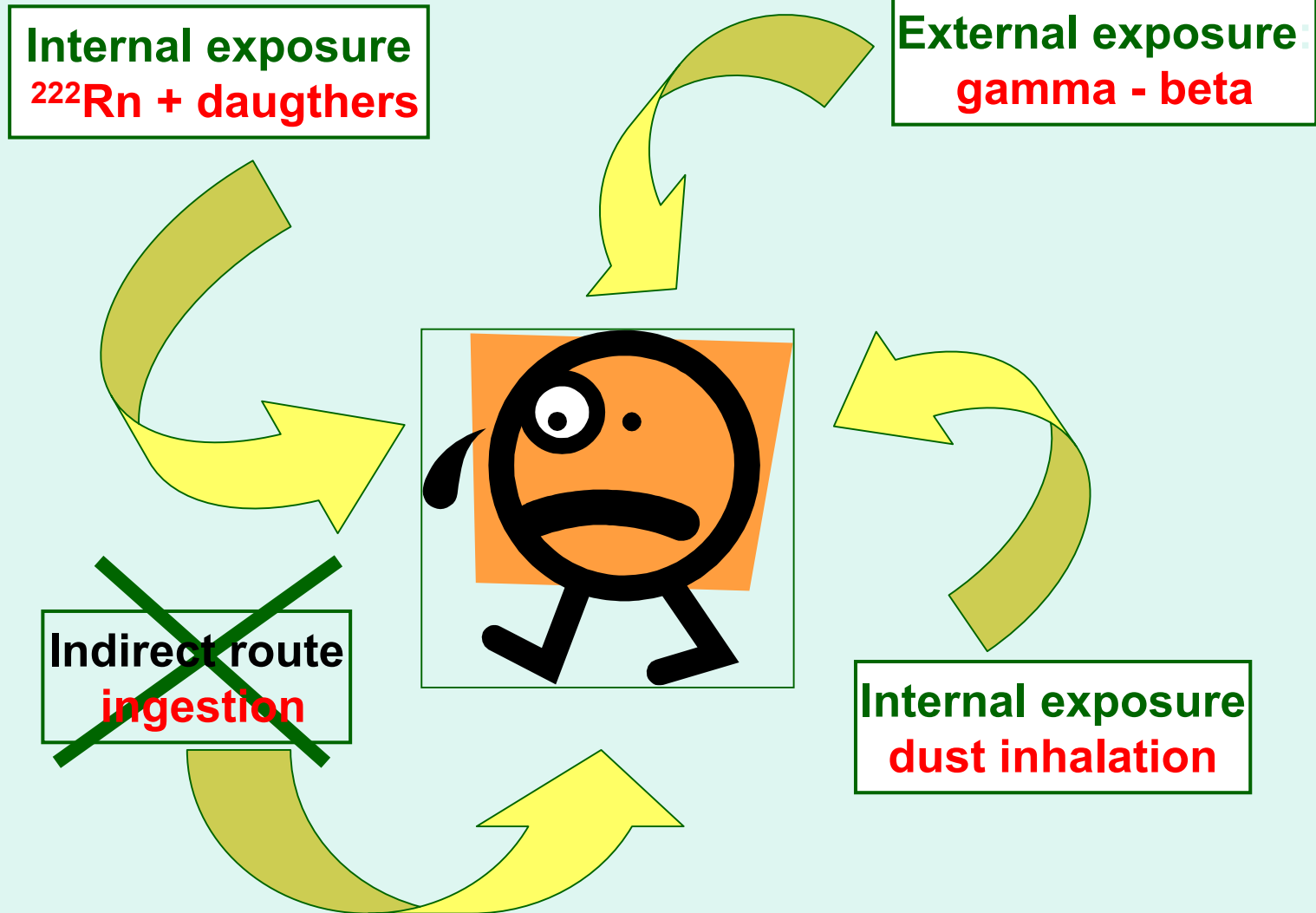


Detector Number	Location	^{222}Rn (Bq/m ³)
<i>D-1</i>	<i>J.PROD</i>	<i>65</i>
<i>D-2</i>	<i>D.AP.</i>	<i>50</i>
<i>D-3</i>	<i>AF 1/2</i>	<i>60</i>
<i>D-4</i>	<i>AF 3/4</i>	<i>57</i>
<i>D-5</i>	<i>D.A.P.</i>	<i>57</i>
<i>D-6</i>	<i>AF 3/4</i>	<i>61</i>
<i>D-7</i>	<i>J.PROD.</i>	<i>90</i>
<i>D-8</i>	<i>C.M.A.</i>	<i>45</i>
<i>D-9</i>	<i>C.M.A.</i>	<i>59</i>
<i>D-10</i>	<i>PR STORE</i>	<i>49</i>
<i>D-11</i>	<i>PR STORE</i>	<i>58</i>
<i>D-12</i>	<i>AF 1/2</i>	<i>55</i>

Fosfatos Huelva



Occupational exposures: PG Piles



Activity concentrations in PG active piles (Bq/kg)

Average concentrations (Bq/kg)			
^{238}U	^{230}Th	^{226}Ra	^{210}Pb
200	550	750	500

Average concentrations (Bq/kg)		
^{228}Ra	^{40}K	^{137}Cs
20	< 20	< 0.7

Activity concentrations in WATERS from PG piles (Bq/L)

Sample	^{238}U	^{230}Th	^{226}Ra	^{210}Po	^{232}Th	^{228}Th	^{235}U	^{40}K
E	200	2.5	0.8	5	1	2.5	9	8
P	180	2.3	0.8	3	0.4	1	8	5

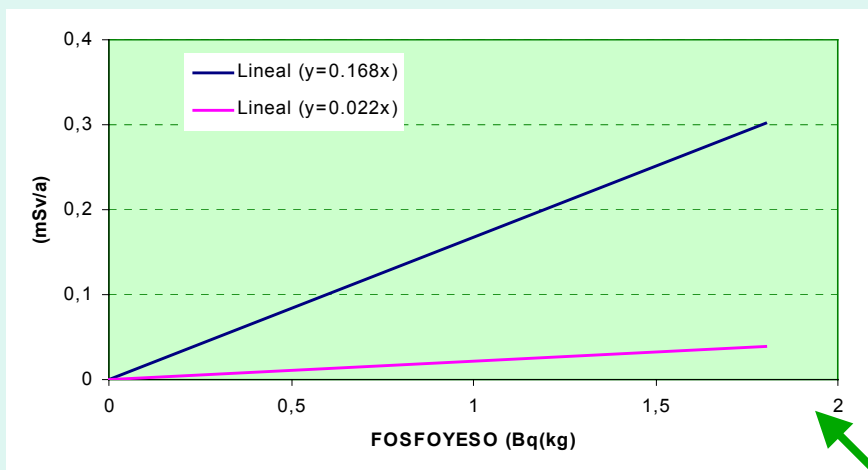
{E} = Water from regulating pool (Bq/L)

{P} = Water from the leachates recovered in perimetral channel (Bq/L)

EXTERNAL GAMMA DOSE RATES



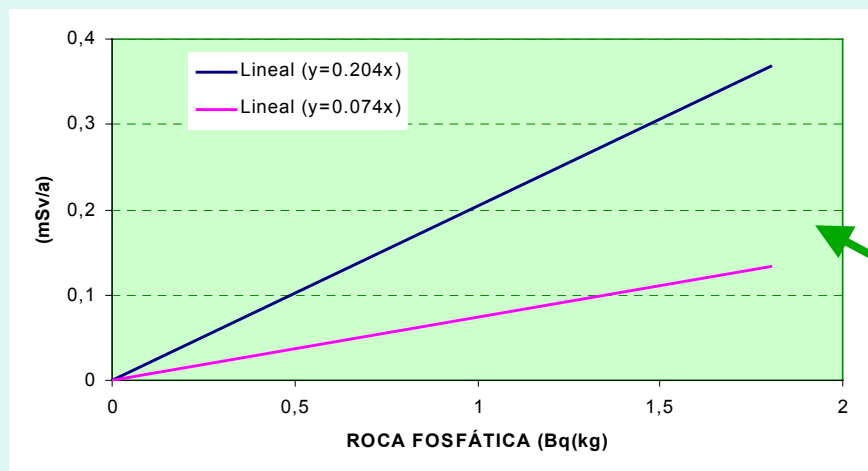
Sampling Point	Increment in effective dose rate external (mSv/y)
1	0.24
2	0.11
3	0.10
4	0.19
5	0.12
6	0.12
7	0.15
8	0.10
9	0.14
10	0.11
11	0.11
12	0.10
13	0.13
14	0.13
15	0.12



**MODELLED
EFFECTIVE DOSES**

— external
— inhalation

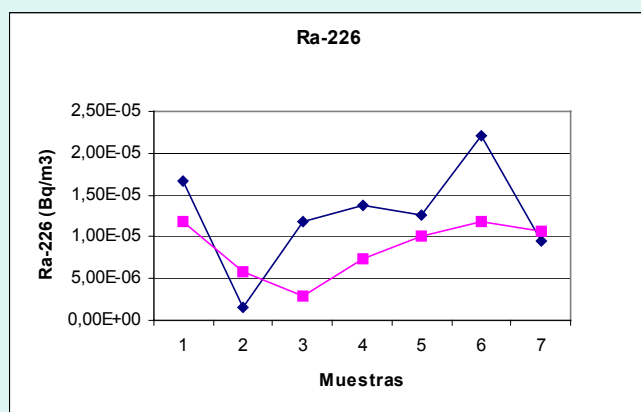
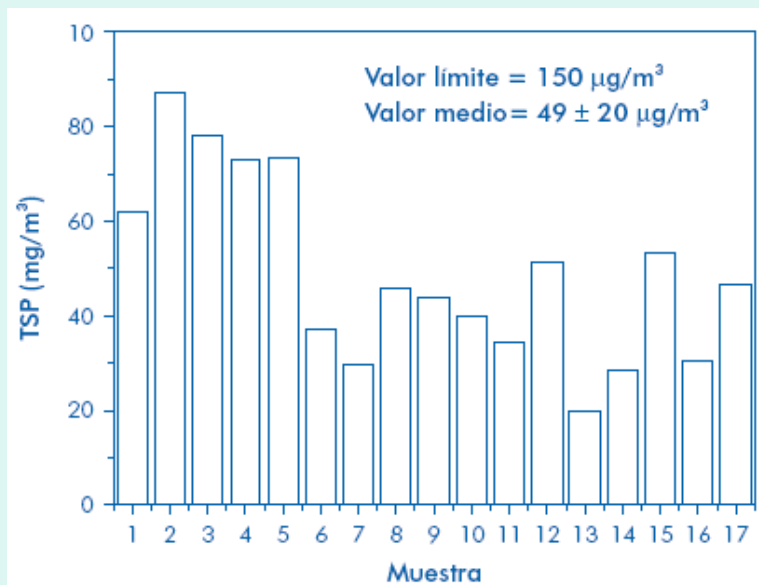
Phosphogypsum Pile



Phosphate Rock Pile

From IAEA Safety Reports Series No. 49 "Assesing the Need for Radiation Protection Measures in Work involving Minerals and Raw Materials" (2006)

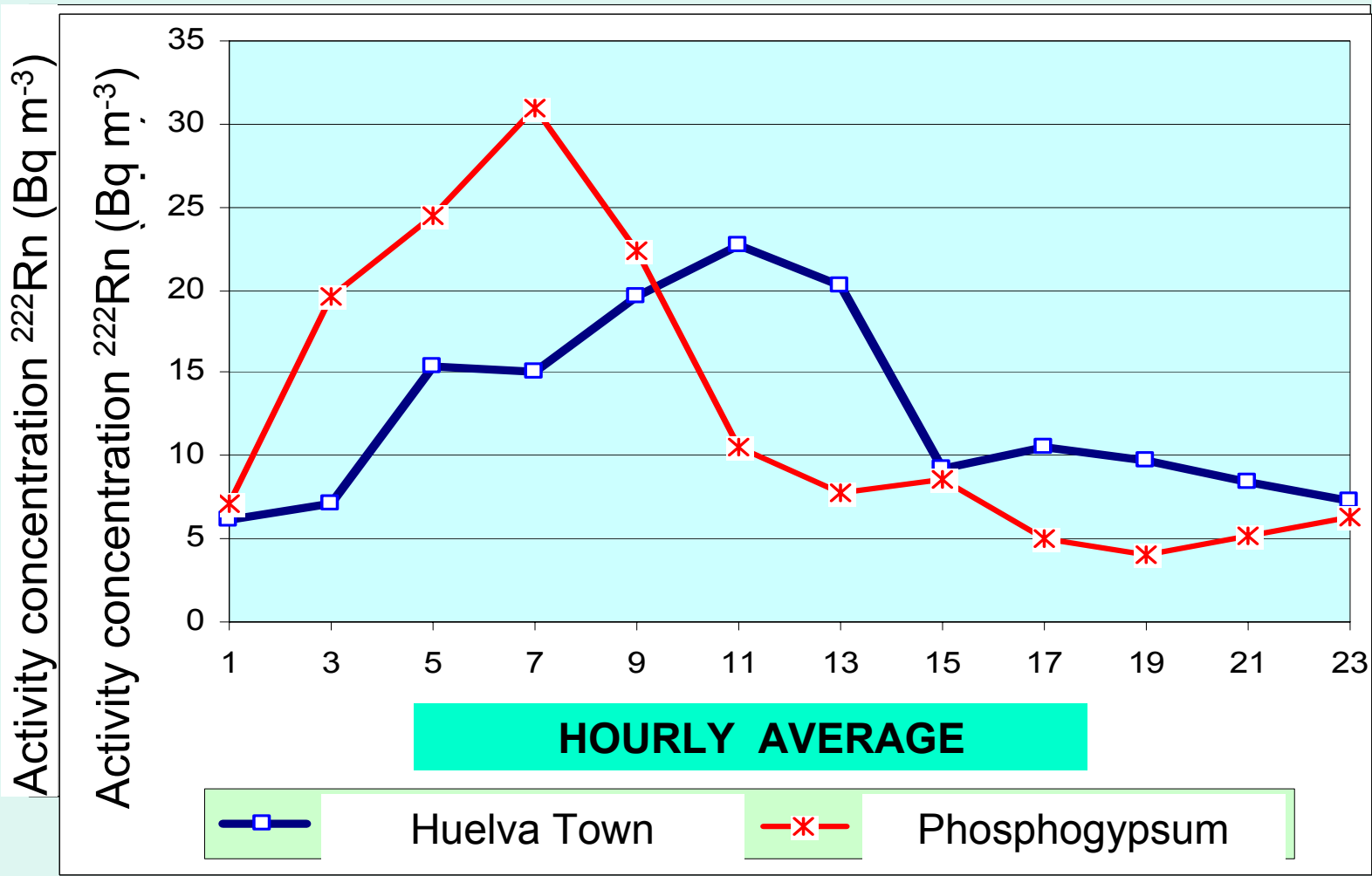
AEROSOL ANALYSIS OVER THE PG PILES



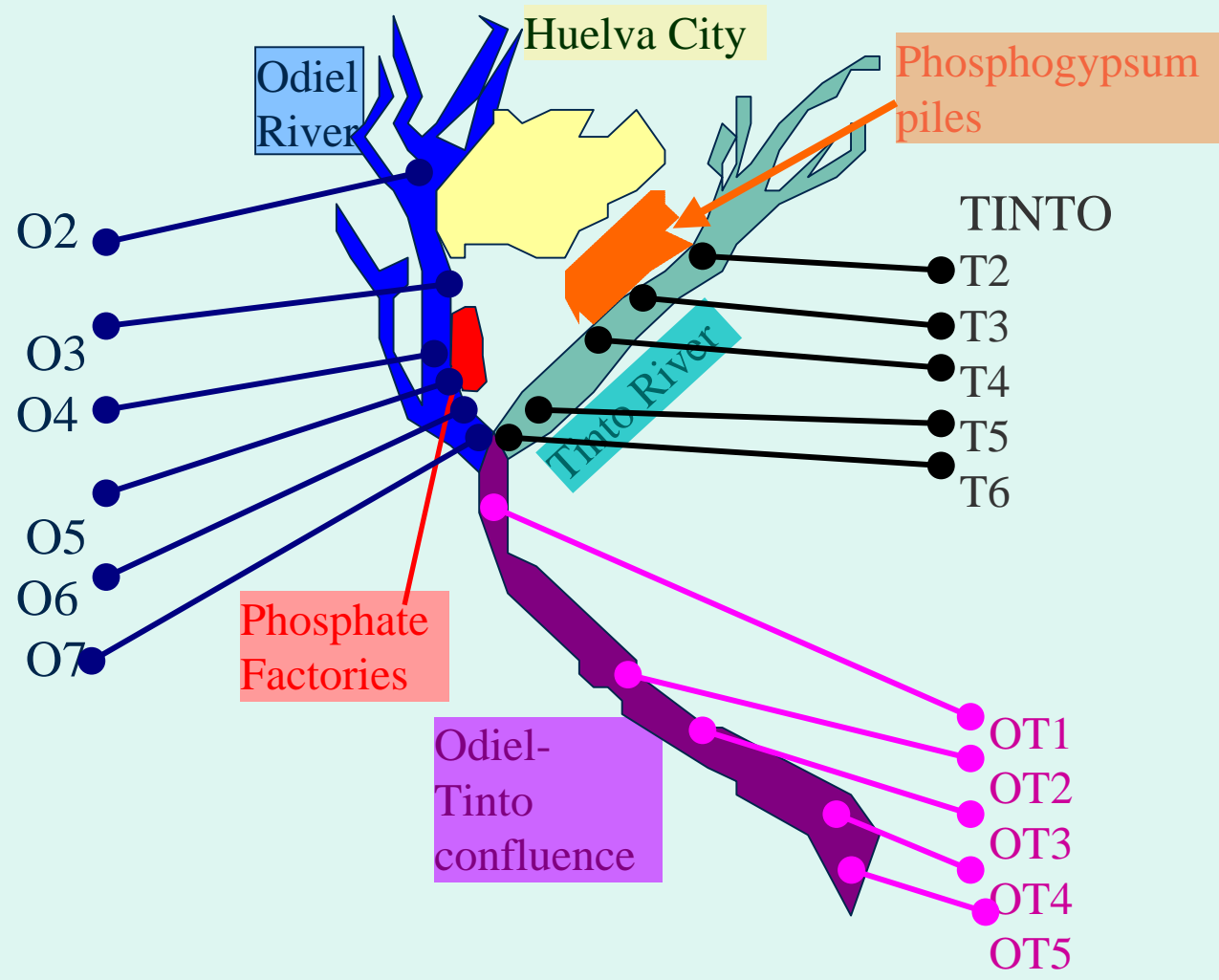
— Phosphogypsum piles
 — Seville Town

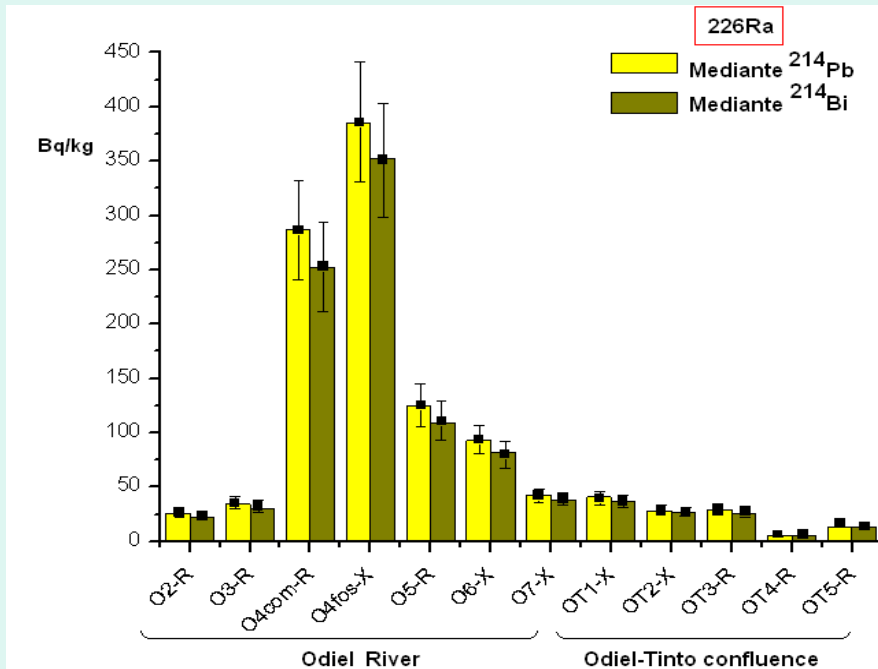
Occupational Radiological impact by inhalation in the PG piles NEGLIGIBLE

RADON DETERMINATIONS OVER PG PILES

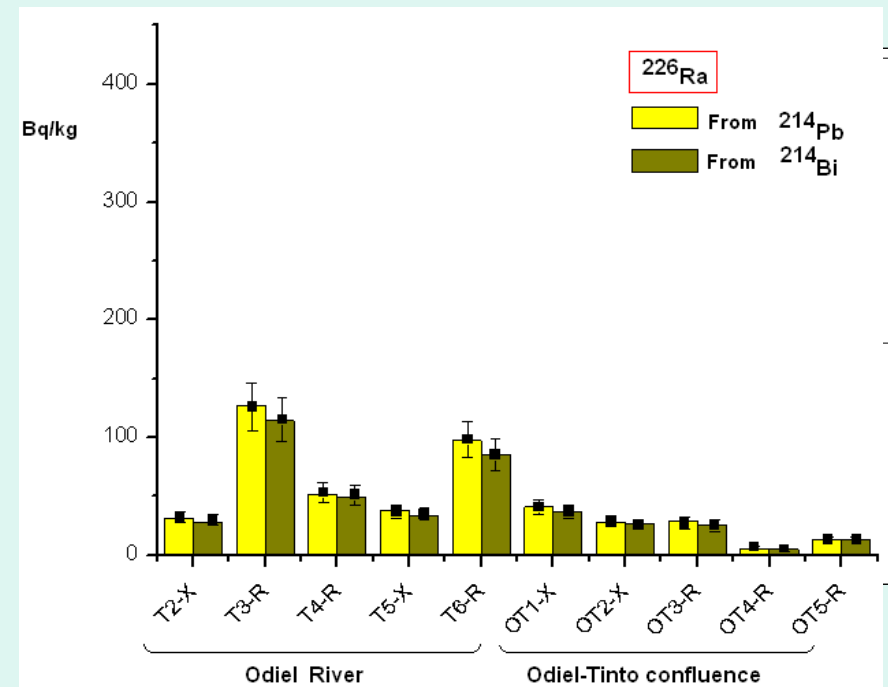


RADIOACTIVE ENVIRONMENTAL IMPACT

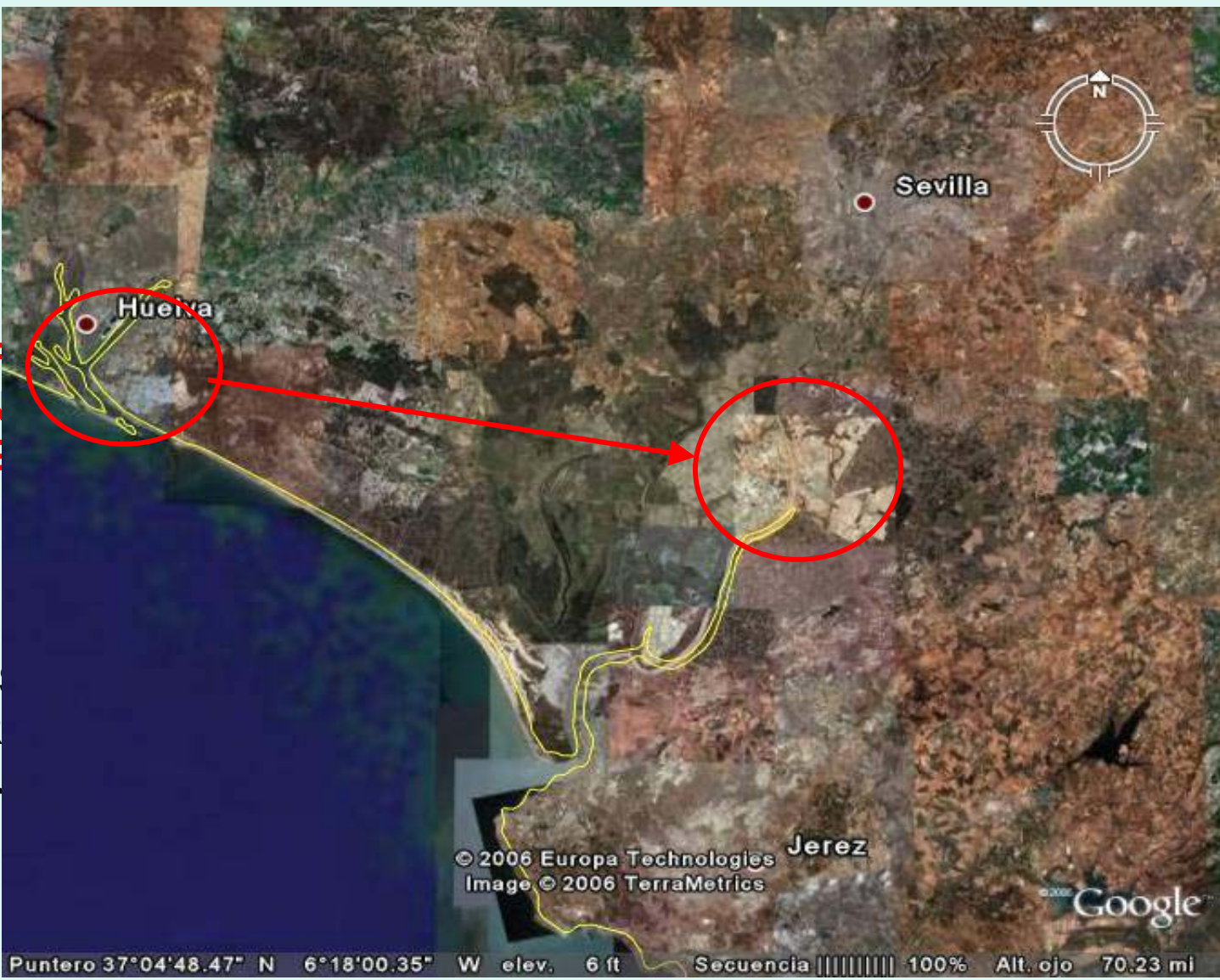




Historic



AGRICULTURAL USE OF PHOSPHOGYPSUM



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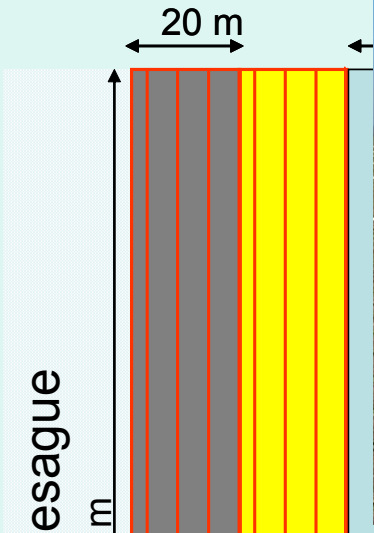
RSH
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2) Microplots experiments have been conducted to study, under controlled conditions, radionuclide and heavy metal soil to plant transfer

The following potential effects of PG have been studied:

- Agronomical effects (biomass production, soil structure, irrigation efficiency, etc)
- ^{222}Rn exhalation in soils,
- Transfer to the vegetal tissues and to the water (tomatoe plants) in areas following PG application,
- ^{226}Ra and ^{210}Po activity profiles in soil, and
- Soil to plant transfer of radionuclides.
- Indirect effects of PG on other elements originally present in the soil.

AGRICULTURAL USE OF PHOSPHOGYPSUM



**FIELD
EXPERIMENT**

1 ha



esague
2



**FIELD
EXPERIMENT**

AGRICULTURAL USE OF PHOSPHOGYPSUM

SOIL TO PLANT TRANSFER

**CONTROL
AREAS**

RADIONUCLIDE

**PG TREATED
AREAS**

TOMATOE FRUITS

Bq/kg	²¹⁰ Po (Bq/kg)	²³⁴ U (Bq/kg)	²²⁶ Ra (Bq/kg)	²²⁶ Ra	²¹⁰ Po
PCA-1				41.1 ± 0.9	28 ± 1
PCA-2	IN PG TREATED SOILS			40.1 ± 1.0	30 ± 1
PCA-3	T11	0.43 ± 0.06	< MDA	< MDA	43.7 ± 1.1
	T19	0.90 ± 0.09	< MDA	< MDA	
PCB-1	T23	0.75 ± 0.11	< MDA	< MDA	49
PCB-2	T27	1.9 ± 0.2	< MDA	< MDA	46
PCB-3	T32	0.68 ± 0.07	0.15 ± 0.04	< MDA	55
	T37	0.45 ± 0.10	0.24 ± 0.04	< MDA	
PCC-1	IN CONTROL SOILS			42.5 ± 0.8	30 ± 1
PCC-1				46.2 ± 1.0	33 ± 1
PCC-3	C2	0.45 ± 0.06	< MDA	< MDA	N.M
	C10	0.43 ± 0.04	< MDA	< MDA	31 ± 1

**MDA U-234:
0.02 Bq/kg**

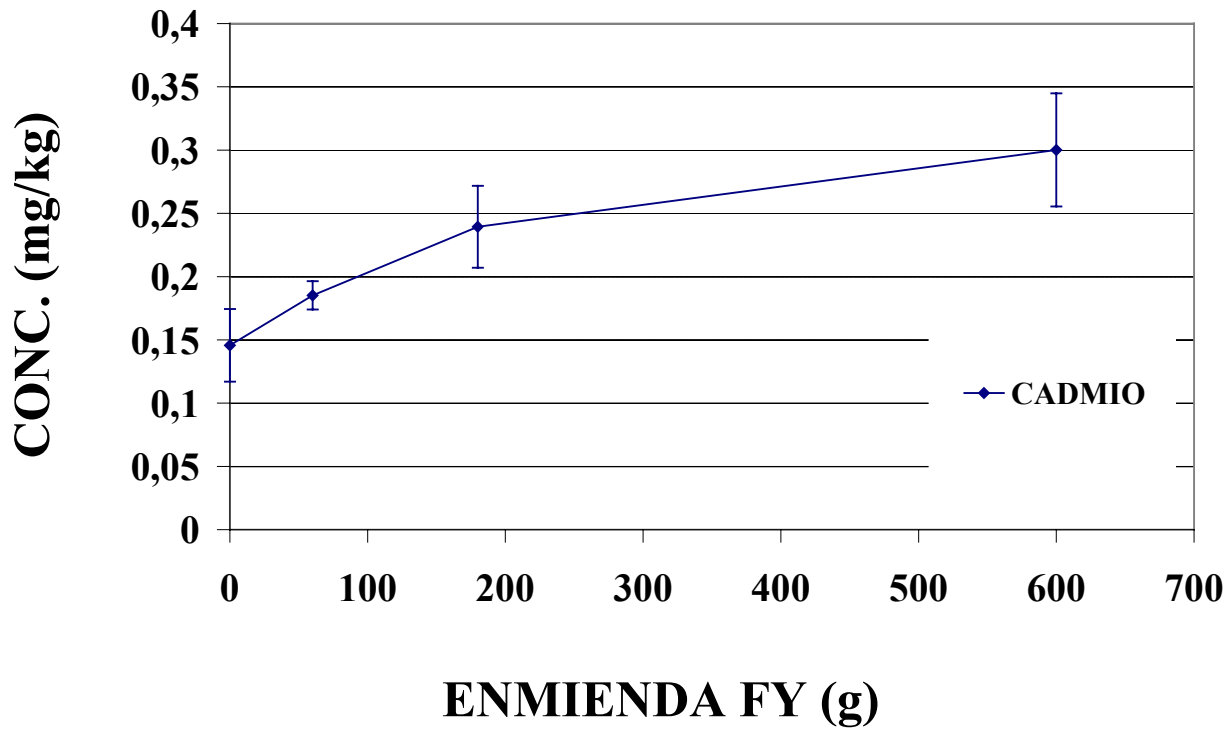
**MDA Ra-226
0.10 Bq/kg**

AGRICULTURAL USE OF PHOSPHOGYPSUM

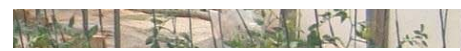
MICRO-PLOTS EXPERIMENTS

EXPERIMENTATIONS WITH TOMATO PLANTS

FRUITS



FROM SW SPAIN).



GROUPS

U and ²²⁶Ra < MDL

usual treatment in

to 3 times usual

d) **Group of treatment T3.** PG added equivalent to 10 times usual treatment in the reclaimed soils (200 Mg. ha⁻¹)

MAIN CONCLUSIONS

The effective doses susceptible to be received by the workers of the analysed Phosphoric Acid plant, under normal working conditions, and by the workers in charge of the maintenance and construction of the PG piles are clearly below 1 mSv/y.

The radioactive environmental impact associated to the activities of the Phosphoric acid plants and the management of the Phosphogypsum is nowadays practically negligible.

From the radiological point of view, it is safe the use of Phosphogypsum in Agriculture as Ca- amendment for sodic soils.

SCIENTISTS PARTICIPATING IN THE PROJECT



Rafael García-Tenorio

José María Abril

Manuel García León

Guillermo Manjón

Santiago Enamorado

Juan Pedro Bolívar

Federico Vaca

José Enrique Martín

Juan Luis Aguado

José Luis Más

FINANCIAL SUPPORT

Spanish Nuclear Security Council (CSN)

Spanish Company of Nuclear Waste Management (ENRESA)

Andalucía regional Government (IFAPA)