

# Determination of Radiation Exposure during the Production of Fertilizers by Measurements

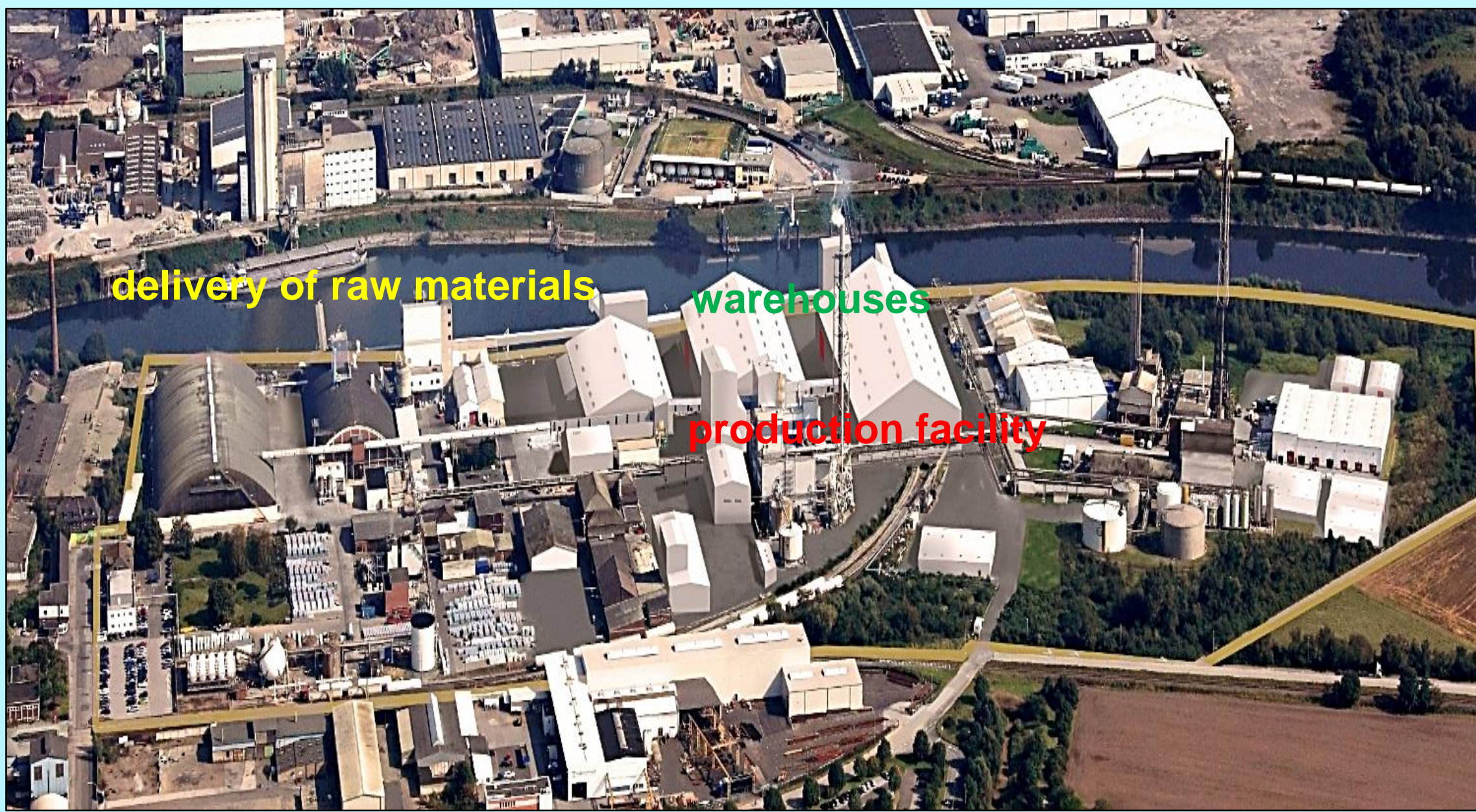


Industrie Service

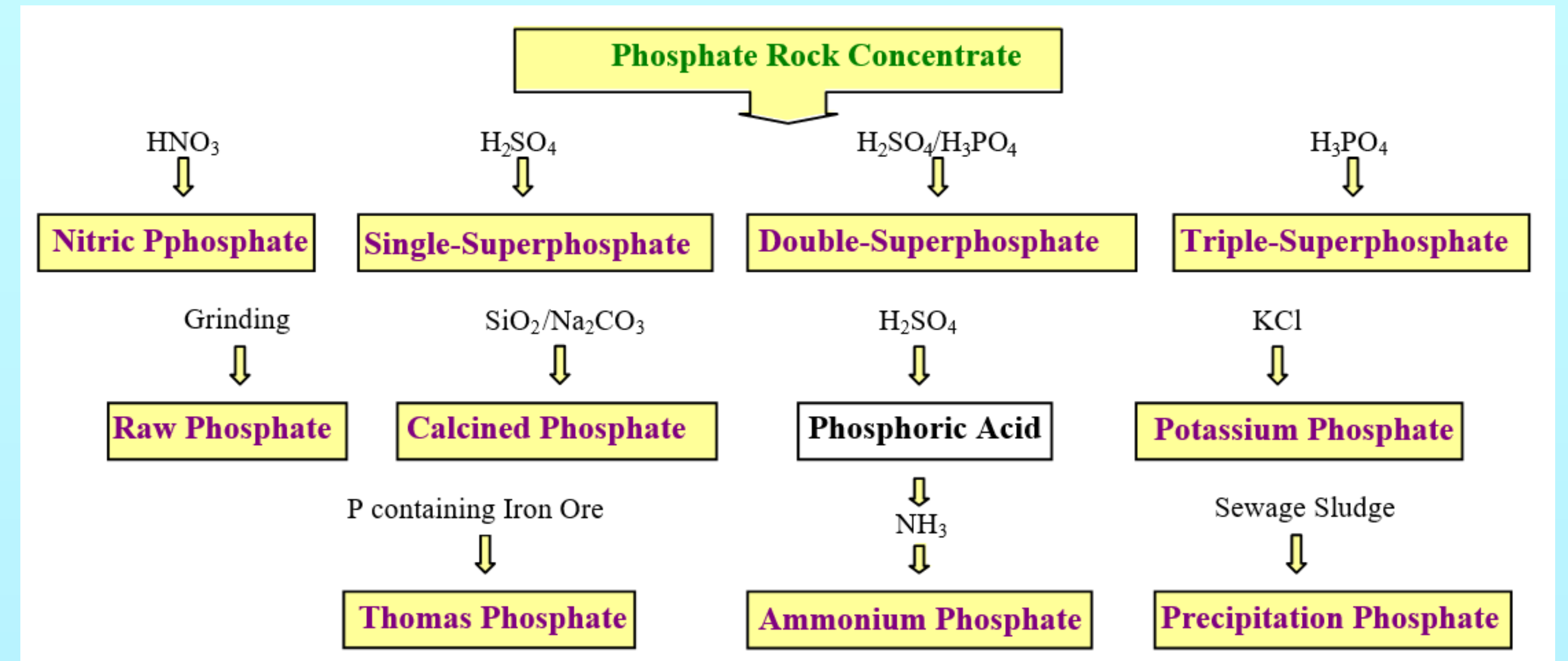
Andreas Reichelt  
TÜV SÜD Industry Services, Munich, Germany

## Introduction

For the production of fertilizers, among other raw phosphates and potassium are used; phosphoric acid is increasingly used. These utilized raw materials contain natural radionuclides in increased concentrations, therefore it must be assumed that the radiation exposure to manufacturing workers is significant and must be taken into account accordingly. For this reason, in a large fertilizer factory radiological examinations have been carried out to determine the radiation exposure of employees in the production of phosphate-containing fertilizers.



The investigated fertilizer factory with large warehouses and the facility for the production of phosphate fertilizers



Overall overview of the types of phosphate fertilizers

## Results

Radio-nuclide <sup>1</sup>	Activity concentration [Bq/kg]											
	1	2	3	4	5	6	7	8	9	10	11	12
Ra-228	30	50	39	19	4	13	86	620	2	2	< 0,9	2
Th-228	27	48	37	20	21	29	86	634	1	2	< 0,2	0,1
U-238	196	593	604	82	19	39	282	150	12	7	3	9
Th-230	278	590	600	89	22	30	301	177	12	8	8	12
Ra-226	221	546	515	73	9	17	275	170	12	2	2	2
Rn-222	201	518	478	66	8	17	240	148	2	2	1	2
Pb-210	299	590	595	81	14	19	286	149	10	13	4	2
U-235	11	29	27	4	1	2	13	7	0,6	0,3	0,1	0,4
Ac-227	10	25	24	1	1	1	13	7	0,4	0,7	< 5	< 3
Pa-231	14	29	29	7	10	1	13	8	0,9	0,4	< 23	< 17
K-40	4436	32	30	3010	4069	3040	3010	80	10475	5369	14273	11466
	13	14	15	16	17	18	19	20	21	22	23	
Ra-228	3	11	5	1	1	2	6	7	53	37	16	
Th-228	1	67	4	0	0,1	0,1	15	8	56	455	17	
U-238	20	45	5	2	8	4	15	10	33	168	32	
Th-230	19	39	6	4	6	6	10	11	33	175	20	
Ra-226	15	2	1	0,6	3	5	1	6	15	1	16	
Rn-222	15	0,1	1	0,4	1	1	1	3	11	0,2	13	
Pb-210	15	0,2	5	0,5	3	1	2	11	25	1	23	
U-235	1	2	0,3	0,1	0,4	0,2	1	1	2	8	1	
Ac-227	1	1	0,8	1,5	< 3	< 4	1	2	2	3	1	
Pa-231	1	2	2	< 10	< 19	< 22	3	5	2	7	5	
K-40	287	56	23	387	12699	12217	105	1804	3589	29	3262	

<sup>1</sup> green: Th-232 series; red: U-238 series; blue: U-235 series; brown: K-40

- filter dust (storage phosphorite from Algeria)
- phosphorite (Algeria) from ship's hold
- phosphorite (Algeria), freshly stored
- filter dust (outsourcing raw materials)
- cyclone dust recirculation
- NPK fertilizer remains, belt scale
- filter dust (storage apatite)
- apatite (South Africa) from ship's hold
- filter dust (outsourcing potassium sulfate)
- filter dust (outsourcing kieserite)
- potassium chloride KCL
- potassium sulphate K<sub>2</sub>SO<sub>4</sub>
- ammonium sulfate (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> (ASU)
- diammoniumhydrogen phosphate (NH<sub>4</sub>)<sub>2</sub>HPO<sub>4</sub> (DAP)
- ammonium sulphate nitrate (2NH<sub>4</sub>NO<sub>3</sub>·(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>) (ASA)
- kieserite Mg[SO<sub>4</sub>]H<sub>2</sub>O
- potassium sulfate K<sub>2</sub>SO<sub>4</sub>
- potassium sulfate K<sub>2</sub>SO<sub>4</sub>
- monoammonium phosphate NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub> (MAP)
- carrier fertilizer
- NPK fertilizer
- wet phosphoric acid H<sub>3</sub>PO<sub>4</sub>
- dust from the bottom of the NPK plant



Mass-related activity of different material samples, taken of raw materials, filter dust, final products and dust from the bottom Examples of raw materials with high activity

Workplace	External radiation exposure	Effective dose E [mSv/a]					
		Internal radiation exposure by inhalation				Total-radiation exposure	
		Aerosolparticle		Rn-222 and decay products		realistic	conservative
Shift foreman	3,00E-02	3,51E-02	5,27E-02	5,00E-02	1,10E-01	<b>1,15E-01</b>	1,93E-01
Spherodizer handling	4,00E-02	3,67E-02	5,46E-02	5,00E-02	1,00E-01	<b>1,27E-01</b>	1,95E-01
Laboratory worker	3,00E-02	3,22E-02	4,84E-02	5,00E-02	1,00E-01	<b>1,12E-01</b>	1,78E-01
Control room engineer	2,00E-02	2,15E-02	3,28E-02	5,00E-02	1,00E-01	<b>9,15E-02</b>	1,53E-01
Cleaner	4,00E-02	4,79E-01	7,07E-01	5,00E-02	1,10E-01	<b>5,69E-01</b>	8,57E-01
Wheel loader driver	4,00E-03	9,74E-02	1,45E-01	6,00E-02	1,20E-01	<b>1,61E-01</b>	2,69E-01
Warehouse worker	4,00E-02	1,15E-01	1,70E-01	5,00E-02	1,00E-01	<b>2,05E-01</b>	3,10E-01
Crane operator	4,00E-02	6,05E-02	9,01E-02	5,00E-02	1,10E-01	<b>1,51E-01</b>	2,40E-01

Effective dose due to external and internal radiation exposure as well as effective total dose to workers in the manufacture of phosphate-based fertilizers when considering realistic and conservative scenarios



Examples of places with dust formation

## Conclusions

The limit of 1 mSv per year is with high probability not exceeded even in unfavorable circumstances, especially as with, a dose reduction by wearing dust masks was not taken into account in the dose calculation.

Even taking into account new dose coefficients according to ICRP 137, the total dose remains below 1 mSv per year under realistic assumptions (maximum dose for the workplace "Cleaner" is 0.92 mSv/a).

Based on the conservative scenarios, the workplace "Cleaner" is likely to exceed the 1 mSv / a limit using the ICRP 137 dose coefficients. In particular, therefore, after publication of all dose coefficients required for the dose calculation in accordance with the new "Human Respiratory Tract Model", we recommend an arithmetical reassessment of the available measurement data.