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Radon research among plaster workers and in the phosphate industry

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RADON RESEARCH AMONG PLASTER WORKERS AND IN THE PHOSPHATE INDUSTRY

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ABSTRACT

A lot of industrial activities may release important quantities of radon gas. Particular groups of workers may incur relatively high doses due to the alpha emitting decay products of radon. Taking into account the high radioactive contents in lots of widely used raw materials of the phosphate industry and its end products; it is obvious to start the research in this area. As some of the end products of the phosphate industry are reused in plaster, research will also be performed among the plaster workers. Detailed measurements of the radioactive content of the raw material and the radon concentration in the most occupied working areas were performed in the phosphate and gypsum industry. As the residence time in the working areas is not stable for different workers, a personal radon dosimeter is designed. It will be tested at its practical usefulness among the plaster workers. Results show that all the measured values are below the ICRP recommendations for workplaces (500 - 1500 Bq/m^3). Most of the firms are aware of the radon problem and have already reduced, on purpose or not, the radioactivity of their basic product.

INTRODUCTION

A lot of industrial activities may release important quantities of radon gas. Particular groups of workers may incur relatively high doses due to the alpha emitting decay products of radon. Results of epidemiological studies among miners demonstrate clearly the causal relation between radon gas exposure and lung cancer incidence. As a consequence, different international organisations (such as the International Commission on Radiological Protection and the Commission of the European Communities) have formulated guidelines and recommendations about radon at work. Nevertheless not many studies have been performed yet about radon exposure at work. Taking into account the high contents of radioactive materials in lots of widely used raw materials of the phosphate industry and its end products; it is obvious to start the research in this area. The aim of the research is to evaluate the possible health risks caused by natural radioactivity. Some of the end products of the phosphate industry are used in the building industry. View to the very specific working conditions, we opted for detailed measurements of the dose acquired during the application of finishing coats based on phosphate products. For this purpose, a new developed dosimeter will be tested at its practical usefulness. The intention is to use this dosimeter in the future for other industries where radon problems could occur.

OBJECTIVES OF THE STUDY

For the evaluation of a possible health risk caused by radon exposure at work, a detailed analysis of the situation at the different working areas where the workers spend most of their time is performed. At first, the (natural) radioactivity contents of the raw material used is analysed with gamma spectroscopy. At the same time, an inventory of the radon exposures in the different working areas is made by means of passive integrating dosimeters. In contrast to the relatively stable residence time in dwellings, the period (and the cumulated dose) spent in different working areas can differ a lot between the workers. Therefore the exposure will also be measured on an individual base for a representative group of workers. Because we only want to determine the accumulated dose during the working hours, the persons concerned in these measurements will have to store their dosimeter at the end of their shift in

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a radon free place, especially prepared for this purpose. The individual dose will be measured with a personal radon dosimeter that is designed for this purpose and consists of a combination of a track-etch detector and activated charcoal. By means of this combination it is possible to increase the sensitivity up to a measurement of 50 Bq/m^3 for one working month (typically 170 h) with an accuracy of 20 %. In parallel with the research at the different production plants, the radon exposure for a representative group of plasterers will be measured during the practice of their jobs where plaster products based on some of the products from the phosphate industry, are widely used. The acquired dose will be determined by means of the results of the personal dosimeter with the help of the characteristics of the measured aerosol distributions. At the same time the usefulness of the ambient air radon measurements, done during the plastering works, for calculating the dose will be investigated.

METHODS

First of all, the long-term measurements (3 to 6 months) may not disturb the industrial activities. On the other hand the selected dosimeters have to be sufficient to determine the radon concentration during the working period. As there is no specific existing dosimeter available, we chose to use the passive diffusion chambers that were mostly used in our studies in dwellings. For more detailed measurements, if necessary, active instruments will be used. We have performed measurements in the 3 biggest phosphate production plants in Belgium. Two of them use sulphuric acid as acidulating agent and one hydrochloric acid. The acid and phosphate ore are mixed under controlled circumstances to obtain the end products. When sulphuric acid is used phosphoric acid is obtained as end product. The phosphoric acid can be used to make fertilisers or other products. The waste product of this process is phosphogypsum. In most of the plants, all over Europe, the phosphogypsum is stored or dumped in the sea or river. In one firm in Belgium the phosphogypsum is recycled in plaster and cement. The alternative, using hydrochloric acid as acidulating agent, is generally applied when hydrochloric is available as by-product from other chemical processes. In this process the cattle-fodder or fertilisers are immediately produced. From radiological point of view the total inventory of U, Ra and Th present in the incoming ore is dissolved and enters the waste stream. The solid waste product is stored next to the factory. Recycling isn't possible due to the high radioactive content. Anticipating on the study of the plaster workers, we also did some measurements in the gypsum industry. First a gamma-analysis of all the different plaster products that are used in Belgium is made. Consequently we could recognise the 'most' radioactive plaster and could choose 'convenient' plaster workers. A total screening was performed in 2 gypsum factories. The first gypsum factory uses natural and sulphogypsum as basic product, the other uses phosphogypsum.

RESULTS

In the phosphate industry, the gamma-activity of the different ore and 'waste' products (Table 1 and 2) is measured. The detection limit of the Ge-detector for a measuring time of 100 000 s is 5 Bq/kg for 226Ra and 232Th and 50 Bq/kg for 40K. (< xx Bq/kg means below detection limit) The firms use phosphate ore of different origins. Firm 1 uses ore of volcanic origin, containing more Thorium than Radium. Firm 2 uses a mixture of volcanic and sedimentary origin. The latter contains a lot more radium. Firm 3 uses purely sedimentary ore. The waste product of Firm 1 has a bigger ?-activity than the basic material because there is still some gypsum on the storage place that is produced with sedimentary ore. As in Firm 3 the end product and effluent contains almost no radionuclides the activity of the waste product is concentrated and larger than the basic product.

Table 1: Gamma-activities of the different phosphate ore in the different firms.

	Activity (Bq/kg)			
	Firm 1	Firm 2 *		Firm 3
		Ore 1	Ore 2	
^{40}K	< 50	< 50	50 ± 5	
^{226}Ra	32 ± 3	64 ± 22	596 ± 71	1095 ± 81
^{232}Th	78 ± 7	204 ± 71	< 5	9 ± 1

* Ore 1 and Ore 2 will be mixed.

Table 2: Activity (Bq/kg) of the waste products in the different firms.

	Activity (Bq/kg)				
	Firm 1			Firm 2	Firm 3
	Zone 1	Zone 2	Zone 5		
^{40}K	66 ± 7	58 ± 6	55 ± 6	76 ± 49	< 50
^{226}Ra	282 ± 39	223 ± 43	53 ± 8	161 ± 7	7320 ± 570
^{232}Th	38 ± 10	53 ± 8	183 ± 38	127 ± 12	51 ± 13

Meanwhile, passive measurements of the radon concentration in the different workplaces, with high occupancy, were started. The results are shown in Table 3. The reference value means a measurement of the radon concentration on a place near the plant where there is no disturbance by the industrial activities. In Firm 1 there is obviously no radon problem. Firm 2 will change its mixture of ore, using only ore of volcanic origin, lowering in this way the total activity, and consequently the radon concentration. Afterwards, new measurements will start, although the values nowadays are all below the ICRP recommendations (500 - 1500 Bq/m^3) for workplaces. The higher activity of the basic and waste materials gives higher radon concentrations in Firm 3. Attention will be paid to these values and control measurements will be performed.

Table 3: Radon concentration (Bq/m^3) in the different working areas.

Working area	Radon concentration (Bq/m^3)		
	Firm 1	Firm 2	Firm 3
Storage of phosfate ore	14 ± 5	84 ± 30	253 ± 12 78 ± 4
Filter room	17 ± 6	216 ± 44 31 ± 13	53 ± 5
Control room	15 ± 5	18 ± 8	
Storage of the end product	10 ± 4	40 ± 28	35 ± 4
Dehydration of the waste product			269 ± 20
Storage of the waste product	33 ± 6 14 ± 5 12 ± 4	70 ± 8 100 ± 24 37 ± 4 22 ± 4	144 ± 6
Reference value	7 ± 4	25 ± 3	19 ± 7

The γ-activity of all the plasters used in Belgium is measured. In Table 4 we give an overview of the activity of the plaster in each factory. Phosphogypsum (Gypsum 4) gives enhance values for radon and thoron but not as extreme as sometimes found in literature. In 2 of the gypsum factories we made a total screening of the plant. In Table 5 the activity of the basic materials is presented. In Table 6 the values of the radon concentration in Gypsum 1 and 2 are represented. In Gypsum 4, which is only a distribution firm, we measured the concentration in the storage room of the end product. Here we can also give the same remarks as in the case of the phosphate industry. All the values are far below and the ICRP recommendations.

Table 4: Activity (Bq/kg) of the different plaster in the gypsum industry.

Activity (Bq/kg)	^{40}K	^{226}Ra	^{232}Th
Gypsum 1	< 50	< 5	< 5
Gypsum 2	< 50	182 ± 18	125 ± 24
Gypsum 3	< 50	10 ± 5	< 5
Gypsum 4	< 50	13 ± 3	< 5

Table 5: Activity (Bq/kg) of the different basic materials of Gypsum 1 and 2.

Activity (Bq/kg)		^{40}K	^{226}Ra	^{232}Th
Gypsum 1	Natural gypsum	50 ± 5	6 ± 5	< 5
	Sulphogypsum (coal)	59 ± 7	11 ± 6	< 5
	Sulphogypsum (brown coal)	65 ± 6	9 ± 5	5 ± 6
Gypsum 2	Gypsum 2.1	< 50	242 ± 22	185 ± 42
	Gypsum 2.2	< 50	267 ± 24	192 ± 53
	Gypsum 2.3	< 50	208 ± 16	121 ± 66

Table 6: Radon concentration (Bq/m^3) in the different working areas of Gypsum 1, 2 and 4.

Working area	Radon concentration (Bq/m^3)		
	Gypsum 1	Gypsum 2	Gypsum 4
Storage gypsum outside	8 ± 3		
Storage gypsum inside	11 ± 6		
Drying building	9 ± 5		
Heating installation	9 ± 5	53 ± 14	
Filling of sacs	8 ± 4	23 ± 4	
Mixer	15 ± 7		
Control room	10 ± 5	28 ± 2	
Oven	10 ± 4		
Scissors	7 ± 2		
Storageroom end product	10 ± 5	28 ± 10	43 ± 6
Gypcompact machine	11 ± 5		
Reference value	9 ± 3	25 ± 3	

CONCLUSION

Most of the firms in the phosphate industry are aware of the radon problem. In the past they have tried, on purpose or not, to reduce the radioactivity of their basic product. Therefore the major problem of radon is already solved. All the measured values are below the ICRP recommendations for workplaces (500 - 1500 Bq/m^3). The problems in the plaster industry are of the same order. In a later study, the effect for the plaster workers will be studied and because of the long occupancy in this environment it could give a radon problem, but probably the dust problem will be the most important one.