NORM IN POLISH INDUSTRY

Skowronek J.[1], Dulewski J.[2]
[1]Central Mining Institute, Katowice, Poland; [2]State Mining Authority, Katowice, Poland

1 ABSTRACT

2 INTRODUCTION

Exposure to a ionising radiation is usually treated by members of general public in Poland as a phenomenon related with nuclear power plants and/or disasters in nuclear installations. The best example was Polish Atomic Law [1], focused till early 90's exclusively on nuclear safety, application of artificial sources of radiation and nuclear accidents. Lately more and more attention is paid to radiation exposure caused by natural radioisotopes. In last several years broad investigations in this field are connected not only with radon exposure in dwellings but also with radiation hazard at workplaces and contamination of the natural environment, caused by non nuclear industries. It has been reflected in the novel of the Atomic Law [2], prepared by Polish Parliament to harmonise Polish regulations with European Union standards [3].
Up to now the specific information on levels of natural radioactivity in waste materials and by-products, created by different branches of Polish industry, are scarce. Therefore it is very difficult to assess the influence of natural radionuclides on exposures at workplaces and pollution of the environment. Only in the hard coal mining the situation is more clear and the better recognised. In this paper we would like to describe the state of the knowledge, concerning this problem in Poland. Results of investigation in exploitation industry will be shown (hard coal mines, copper ore mines, lead and zink mines and salt mines) as well as data from processing industries (dealing with fertilisers, power generation and production of construction materials).
In first part of the paper results of measurements of the most important natural radionuclides (^{226}Ra, ^{228}Ra and ^{40}K) in different materials are gathered – raw materials, waste and by-products, produced or dumped into natural environment. In the second part the assessment of the doses for workers, exposed to sources of natural radiation in different branches of industry, will be done.

3 NATURAL RADIOACTIVITY OF RAW MATERIALS AND INDUSTRIAL SPOILS

In table 1 the main branches of the exploitation industry in Poland are shown. The annual production of raw materials is of about 219 mln tonnes [4]. Moreover, roughly 82 mln tonnes of solid spoils is dumped onto the surface per year. Additionaly, about 2,9 mln cubic meters of waste water is pumped out daily [16].
The production of phosphate fertilisers is based on imported phosphates (slightly more than 0.5 mln tonnes per year). Waste materials, generated in

power industry, must be also taken into account – of about 13 mln tonnes annually.
There are no complete data of natural radioactivity of raw and waste materials in mentioned above branches of industry. The most reliable results come from mining industry, because investigations in that filed have been performed in hard coal mines, metal ore mines and other underground mines since 30 years. At the end of 80's in whole underground mining the system of radiological protection against natural radionuclides has been implemented. At the beginning of 90's requirements of radiological protection in mines has been issued as the Decree of Polish Parliament [5].

Table. 1. Production of raw and waste materials in Poland

<table>
<tr><th>Branch of the industry</th><th>Production, mln tonnes/year</th><th>Solid waste, mln tonnes/year</th><th>Liquid waste, mln m^3/daily</th></tr>
<tr><td>Coal mining</td><td>112</td><td>40</td><td>0,58</td></tr>
<tr><td>Copper ore mining</td><td>28,4</td><td>25</td><td>0,06</td></tr>
<tr><td>Lead and zinc mining</td><td>5</td><td>4</td><td>0,44</td></tr>
<tr><td>Limestone quarries</td><td>8</td><td>3</td><td>0,50</td></tr>
<tr><td>Salt mines</td><td>4,2</td><td rowspan="3">10</td><td>0,16</td></tr>
<tr><td>Lignite open pit mines</td><td>60,8</td><td>1,26</td></tr>
<tr><td>Oil</td><td>0,4</td><td>0,0004</td></tr>
<tr><td>Power generation</td><td>-</td><td>13</td><td>-</td></tr>
<tr><td>Phosphate fertilisers</td><td>0.5</td><td>?</td><td>-</td></tr>
</table>

Table. 2. Maximum concentration of radionuclides in different product of hard coal mining industry [8,9,10]

Product	Ra-226	Ra-228	K-40
Hard coal, Bq/kg	159	123	785
Waste rocks, Bq/kg	122	106	1797
Scales, precipitated out from waste waters, Bq/kg	204127	83785	
Brines, kBq/m^3	391	99	-

Table. 3. Maximum concentration of radionuclides in different product of copper ore mining industry [9,11,12,17]

Product	Ra-226	Ra-228	K-40
Copper ore, Bq/kg	75	20	466
Concentrated ores after flotation, Bq/kg	145	20	688
Waste rocks, Bq/kg	53	43	676
Waste products from flotation processes, Bq/kg	98	39	1243
Scales, precipitated out from waste waters, Bq/kg	1340	68	
Copper slag, Bq/kg	401	183	1251
Brines, kBq/m^3	95	12	-

Table. 4. Maximum concentration of radionuclides in different product of zinc and lead ore mining industry [9,13]

Product	Ra-226	Ra-228	K-40
Zinc ore, Bq/kg	21	17	65
Waste rocks, Bq/kg	40	17	194
Waste products from flotation processes, Bq/kg	26	16	80
Scales, precipitated out from waste waters, Bq/kg	76	61	
Brines, kBq/m^3	0,5	0,1	-

Table. 5. Maximum concentration of radionuclides in different product of salt mining industry [9]

Product	Ra-226	Ra-228	K-40
Brines kBq/m^3	0,3	0,5	-

Table. 6. Maximum concentration of radionuclides in different products of power industry [12]

Product	Ra-226	Ra-228	K-40
Slag, Bq/kg	482	210	1260
Fly ash, Bq/kg	395	206	1664

Table. 7. Maximum concentration of radionuclides in different product of phosphate industry [12,14]

Product	Ra-226	Ra-228	K-40
Phosphates, Bq/kg	870	136	1110
Fertilisers, Bq/kg	58	145	8110
Phosphogypsum, Bq/kg	620	48	680

Table. 8. Maximum concentration of radionuclides in different product of metallurgical industry [12]

Product	Ra-226	Ra-228	K-40
Slag, Bq/kg	351	115	1400

Systematic obligatory measurements enabled to gather a broad database of results of concentrations of natural radionuclides in air, water and solid materials not only in underground galleries but also in the natural environment in the vicinity of mines. The most complete database exists for hard coal mining industry (see table 2) [6,7]. Fewer data have been gathered for copper ore mines (table 3) and lead and zinc mines (table 4). Additionally, in table 5 results from salt mines are presented. Table 6 contains data for waste materials from power industry, while in table 7 some results from phosphate fertilisers industry have been shown. Finally, in table 9 data for spoils from metallurgical industry have been presented.
Accordingly to the presented data, in almost all raw materials, produced by Polish mining industry (like metal ores and hard coal), typical concentrations of natural radionuclides are low. Nonetheless, in some cases we observe radium concentrations above value 50 Bq/kg, quoted in UNSCEAR reports as the upper limit for the Earth's crust. Only in phosphates, imported to Poland, much higher concentration of radium isotopes has been measured, up to 1000 Bq/kg.

Quite opposite is the situation of waste products, especially from mining industry. Upper Silesian Coal Basin has rather specific geological and mining conditions, therefore inflows of brines with high radium content into underground galleries are numerous. De-watering of mines (removal of these brines from mines onto the surface and further to rivers) causes the contamination of the natural environment in the vicinity of coal mines. Sometimes in these brines not only radium bat barium ions are present and then radium co-precipitates with barium in form of highly radioactive scales. Such processes can be observe not only in the underground workings, but also

sometimes on the surface, in settling ponds or rives, mainly in cases, when wastewaters have been not treated before dumping into rivers. Such contamination of the environment is a potential source of radiation hazard not only for miners but also for the inhabitants of adjacent lands. Similar problems have been found in copper ore mines and in their vicinity.
Another problem is connected with monitoring of radioactivity of construction materials. Such measurements are obligatory in Poland since late 70's and results have been regularly published since 1980 [12].

Table 9. Natural radionuclides in construction materials in Poland, Bq/kg

Product	Ra-226	Ra-228	K-40
Marble	10	7	51
Chalk	42	14	295
Gypsum	64	30	279
Limestone	36	23	540
Lime	47	19	331
Sand	75	76	686
Marl	37	27	396
Clinker	121	41	534
Mudstone	130	141	1241
Clay	161	127	938
Shale	116	219	1925
Cement	154	138	608
Concrete	200	127	1005
Tiles	190	130	1410

4 RADIATION HAZARD AT WORKPLACES

Occurrence of natural radionuclides at workplaces is the source of the radiation hazard for workers. The most important natural radionuclide is obviously radon and radon progeny, while other sources are: external gamma irradiation or accidental ingestion and inhalation of long lived nuclides. In Polish mining industry monitoring of all possible sources of expose at workplaces in

underground galleries is obligatory, but in other branches such measurements have been done only occasionally.
In following tables results of assessment of dose equivalents in different branches of industry has been presented – for coal mining, copper ore mining, lead and zinc mining and in phosphate fertilisers industry. The assessment is done for the exposure from radon progeny, gamma rays and internal contamination.

Table. 10 Maximum dose equivalents in coal mines (1995-2000) [7]

Source of hazard	Dose equivalent, mSv/year
Radon progeny	7,2
Gamma dose	1,8
Internal contamination, radium isotopes	4,2

Table. 11 Maximum dose equivalents in metal ore mines [7,15]

Source of hazard	Dose equivalent, mSv/year
Radon progeny	9,6
Gamma dose	0,08

Table 12. Maximum doses in phosphate industry [14]

Source of hazard	Dose equivalent, □Sv/year
Radon progeny	0,18
Gamma dose	0,35

5 SUMMARY

Worldwide the exposure to radon progeny is usually treated as the only one source of radiation hazard at workplaces. The same situation can be observed in Polish exploitation and power generation industry, except underground mining. Due to high concentration of radium isotopes in brines and co-precipitation of radium and barium as highly radioactive scales, the gamma radiation and internal contamination could be important source of hazard. Additionally, the release of radium bearing waters and deposits leads also to the contamination of the natural environment in the vicinity of mines. The pollution may cause the increase of the exposure for the inhabitants of adjacent lands. The maximum dose equivalents for the members of the Upper Silesian population have been calculated at the level of few mSv per year.

6 REFERENCES

1. Atomic law, Dz. U. Nr 12, poz. 70, 1982 (in Polish)

2. Atomic Law. Dz.U. nr 3, poz. 18, 2000 (in Polish)

3. EU Council Directive 96/29/Euroatom „The EC Basic Safety Standarts”

4. Statistical yearbook 2000. GUS, Warszawa, 2001

5. Geological and mining law, 1994 (in Polish)

6. Skowronek J.: Radiation exposures to miners in Polish coal mines. Radiation Protection Dosimetry, vol. 82, No 4. Pp. 293-300 (1999)

7. Skowronek J.: Annual report (2000) on radiation hazard. Central Mining Institute, Katowice, 2001 (in Polish)

8. Wysocka M., Skowronek J.: Natural radioactivity of hard coal in Rybnik-Jastrzębie region. Publs. Inst. Geophys. Pol. Acad. Sc., M-15 (235), 1991 (in Polish)

9. Databases, Central Mining Institute, Katowice.

10. Wysocka M., Skowronek J.: Investigation on the radioactivity of carboniferous strata in Upper Silesia. Central Mining Institute, Katowice, 1988 (in Polish)

11. Wysocka M., Michalik B., Stec K. et al.: Changes od radon concentration in relation to mining activity. Central Mining Institute, Katowice, 1997 (in Polish)

12. Environment 2000. GUS, Warszawa, 2000

13. Girczys J., Skowronek J., Źródłowski B.: Spectrometrical analysis of Zn-Pb ores. Zesz. Nauk. Polit. Śl., seria górnictwo, zesz. 122 (749), 1983 (in Polish)

14. Chruścielewski W., Olszewski J., Kamiński Z.: Radiation hazard in phosphate industry. Medycyna Pracy, L, 1999, 5 (in Polish)

15. Kluszczyński D., Kacprzyk J.: Estimation of radon progeny hazard in metal ore mines. Raport IMP, Łódź, 2001 (in Polish)

16. Report on mine waste waters. State Mining Authority, Katowice, 2001 (in Polish)

17. Muras K., Olszewski J.: Determination of natural ionizing radiation exposure in the surroundings of copper mines in Poland. Medycyna Pracy, XLIV, 1993, No 4