A study concerning NORM in integrated steelworks

F. Trotti[1], C. Zampieri[1], E. Caldognetto[1], R. Ocone[2], A. Di Lullo[2], L. Magro[2], G. Jia[2], G. Torri[2]

[1] ARPAV: Regional Agency for the Environmental Protection of Veneto
via A. Dominutti 8, 37135 Verona
Email: czampieri@arpa.veneto.it ; ftrotti@arpa.veneto.it

[2] APAT: Agency for the Environmental Protection and for Technical Services
via V. Brancati 48, 00144 Rome

Italy

Abstract. Integrated steelworks are significant as far as NORM is concerned, as confirmed by literature data indicating enrichment in natural radionuclides during some steps of steel production. A study concerning an integrated steelworks was performed by the Regional Agency for the Environmental Protection of Veneto (ARPAV) together with the National Agency for the Environmental Protection and for Technical Services (APAT). The main steps of the standard working cycle for integrated steelworks are described. Natural radionuclide activity concentration measurements were carried out in samples from two integrated steelworks (coke production residues, blast furnace dust and sinter dust). Enhanced levels of ^{210}Pb and ^{210}Po are recorded for some dust and residue samples; elevated values of these nuclides (more than 40 Bq/g) are shown in sinter dusts, suggesting the development of estimates of the dose delivered to population in their environmental path.

1. Steel production in integrated steelworks

Iron and steel production from iron ore is well known: ores, coke and melting materials are fused at 2000°C in a blast furnace to give pig iron, which is further converted in steel; coke is prepared through coal distillation at 900°C; iron ores are usually subject to sintering before use in the blast furnace, a thermal process (1400°C) aimed at obtaining adequate size and physical resistance.

Dust is generated in thermal processes (coke distillation, sintering, blast furnace fusion), partly precipitated, partly emitted in air, water and tar are formed as residues of coke production. These dusts and residues may have a natural radioactivity content, transferred from iron ores, that could be of some interest from the radiological point of view. In the literature, elevated values of ^{210}Pb and ^{210}Po are reported in dust from sinter and blast furnace processes as a result of enrichment following volatilization [1]. Similar cases, on the other hand, occur in other high temperature treatments, such as zircon sand fusion for refractory material production [2].

In Italy, only four integrated steelworks still operate [3]; ARPAV has carried out a small survey on two of these in 2004–2005, collecting samples of dust and residues of the kind just mentioned; the assessments of radioactivity content are presented.

It should be noted that the sintering process was active in one plant only (plant 1).

2. Sampling and analytical methods

Samples of various materials were collected in the two plants, in 2004 for plant 1 and in 2005 for plant 2: material details are given in Tables 1 and 2. The samples were analysed by gamma spectrometry by ARPAV for ^{238}U, ^{226}Ra, ^{235}U, ^{232}Th and ^{40}K while APAT produced estimates of the ^{210}Pb and ^{210}Po content through radiochemical analysis. ^{238}U was assessed through its decay product ^{234m}Pa; ^{226}Ra through its decay products ^{214}Pb and ^{214}Bi and, in this case, secular equilibrium was restored by keeping samples in a sealed aluminium beaker for a month; also ^{232}Th was derived through its gamma-emitting decay products. As far as gamma spectrometry is concerned, the coincidence summing, in particular for ^{214}Bi, and self-attenuation effects, have been corrected through GESPECOR software. The determination of ^{210}Pb and ^{210}Po activity concentrations was carried out by APAT. The radioanalytical methods were based on (a) sample pretreatment (b) radionuclide separation and (c) source preparation. Finally ^{210}Po was counted by α-spectrometry and ^{210}Pb by a low background beta counter.

3. Results and discussion

Activity concentrations for all samples are shown in Tables 1 and 2. The 68% confidence level uncertainties are given in brackets. The data refer to the year of measurement (2005 for plant 1 and 2006 for plant 2).

TABLE 1. ACTIVITY CONCENTRATIONS IN MATERIALS FROM AN ITALIAN INTEGRATED STEELWORKS (PLANT 1)

	Activity concentration (Bq/kg)						
	^{238}U	^{226}Ra	^{210}Pb	^{210}Po	^{235}U	^{232}Th	^{40}K
Tar (coke production)	3 (24)	<0.3	181 (10)	177 (10)	<0.7	1 (19)	<3.0
Blast furnace dust (sample 1)	18 (22)	26 (7)	665 (10)	632 (10)	<1.0	11 (7)	83 (6)
Blast furnace dust (sample 2)	20 (22)	22 (7)	1583 (10)	1544 (10)	6 (34)	11 (8)	242 (6)
Sintering dust (common electrostatic precipitator)	27 (22)	32 (6)	1167 (10)	1058 (10)	2 (27)	5 (11)	180 (6)
Sintering dust (weep electrostatic precipitator)	<15	24 (7)	47 243 (10)	42 867 (10)	< 4,0	7 (19)	6219 (5)

Note: Percentage uncertainties at the 68% confidence level are shown in parentheses.

TABLE 2. ACTIVITY CONCENTRATIONS IN MATERIALS FROM AN ITALIAN INTEGRATED STEELWORKS (PLANT 2)

	Activity concentration (Bq/kg)						
	^{238}U	^{226}Ra	^{210}Pb	^{210}Po	^{235}U	^{232}Th	^{40}K
Coke quenching water	<5.0	<0.3	13 (30)	7 (20)	<0.8	0.3 (16)	3 (11)
Coke oven take out dusts	21 (23)	15 (8)	14 (20)	2 (15)	6 (32)	10 (9)	30 (9)
Blast furnace dust (secondary off gas at filterpress)	17 (23)	15 (7)	1461 (15)	1146 (10)	<1.1	5 (9)	30 (8)
Blast furnace dust (primary off gas at APO)	8 (24)	13 (8)	324 (15)	296 (10)	<1.2	6 (9)	67 (7)

Note: Percentage uncertainties at the 68% confidence level are shown in parentheses.

For plant 1, enhanced concentrations of ^{210}Pb and ^{210}Po are shown in all samples, reaching particularly high levels in dust from the sintering process (weep precipitator); all other nuclides of natural origin are at moderate or low concentrations. In plant 2, where the sintering process is not present, an increase of ^{210}Pb and ^{210}Po in blast furnace dust is observed, similar to that occurring in plant 1 (and again no anomalies appear for the remaining radionuclides). Generally, the high values in dust of ^{210}Pb and ^{210}Po depend on the enrichment due to volatilization in the high temperature processes.

These results indicate that care is need when dealing with residues from thermal processes of integrated steelworks, both for dust emitted into the atmosphere from the stacks and those destined for disposal as solid waste. This is particularly true for dust produced in the sintering process.

The dose received by the local and global population for releases into the air and for leaching at disposal sites is being calculated using specific modelling codes.

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