COAL-FIRED POWER PLANT: AIRBORNE ROUTINE DISCHARGES

Background

The radiological impact from non-nuclear industries is a growing matter of concern to stakeholders and regulators. It has been demonstrated that atmospheric discharges from coal-fired power plants can lead to higher dose-impacts to critical groups of the population than nuclear power plants. In Belgium, in the frame of an agreement between electricity producers and national authorities, measures were taken in conventional power plants to restrict airborne discharges of SO_2, NO_X and suspended particles. In the 500 MWe coal-fired power plant of Langerlo, a flue gas purification system was installed, consisting of a denitrification unit and a desulphurisation unit, next to the electrostatic dust filter units. These measures have also an important effect on the radioactive atmospheric discharges.

Objectives

The objective of this study was to assess the radiological impact of the airborne releases of the power plant under normal working conditions and in particular the influence of the installation of the flue gas purification system.

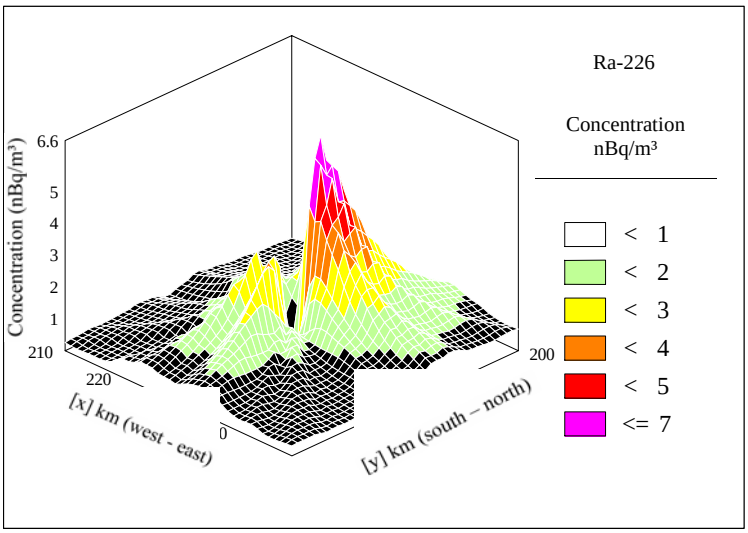
Methods

As a first step, we measured the natural radioactivity content of the coal and the radium content of the fly ash . The quantities of the other radioelements discharged through the chimney, were estimated, assuming the same behaviour as radium, except for the more volatile lead and polonium, which will condense preferably on finer ash particles, against which the electro filters are less effective. (A concentration factor of 4 has been adopted). The radon, present in the coal, is assumed to be discharged completely through the chimney.

The atmospheric transport, dispersion and deposition of the discharged radionuclides were modelled, applying the bi-Gaussian plume model IFDM (by Vito). For the calculations, we used hourly averages of the meteorological observations at Mol over the year 1991.

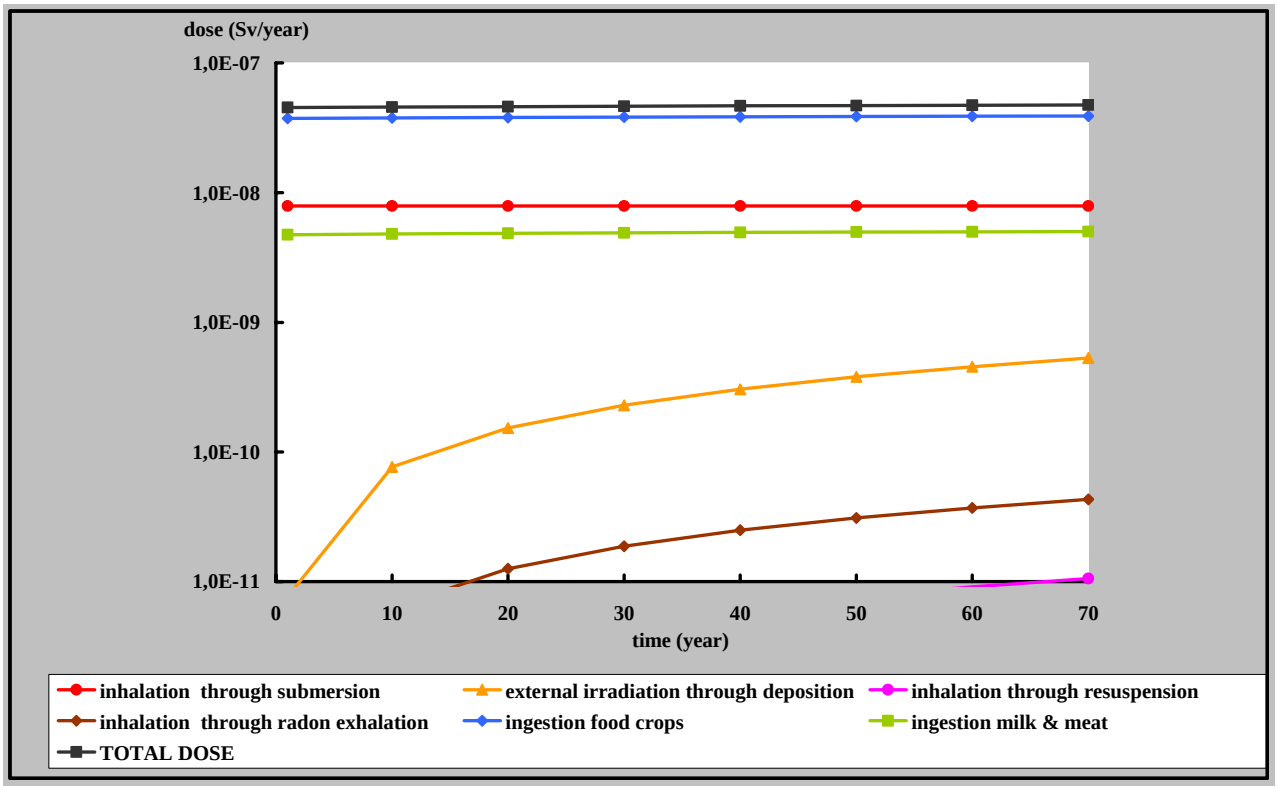
The transfers of the radionuclides from air and soil to the biospheric media, exposing man, were calculated with our biosphere model and the radiological impact to the critical group assessed. This group is considered to consist of self-sustaining farmers, having their fields in the zone of the highest annual air concentrations and depositions. The doses from the direct exposure by the plume (external irradiation and inhalation) were calculated straight-away from the maximum concentrations of ^{226}Ra and the other radionuclides of the natural decay chains in the plume. For the doses from the deposition onto the soil, the accumulation of the radionuclides in the soil with time, has to be estimated, over the life span of the power plant (assumed to be 70 years).

Principal results



Concentration values of ^{226}Ra in air for the measured discharge value of 2002 (1100 Bq/kg). When taking into account the average ^{226}Ra concentration in the discharged fly-ash of 700 Bq/kg, the maximum annual concentration in air becomes 4.5 nBq/m³ and the maximum annual deposition 1.5 mBq/m²y.

The mean concentrations of ^{226}Ra and ^{232}Th measured in the coal fall within the normal range (20 – 25 Bq/kg) observed globally for good-quality coal. The average radium content of the fly-ash passing through the electro filters was 700 Bq/kg, which is rather high when comparing it with the fly-ash at other coal-firing power plants. However the total amount of ^{226}Ra discharged and normalized to the unit power generated, was lower than that of most other installations by 1 or 2 orders of magnitude. The maximum annual value of the ^{226}Ra concentration in the air calculated with the IFDM model is 4.5 nBq / m³ and the maximum annual value of the total deposition is 1.5 mBq / (m².y).



Time-evolution of annual individual effective doses to the critical group for pathways from direct exposure to the plume and pathways from deposition on the ground. The direct external irradiation from the plume is not indicated (below scale). The flat evolution of the total dose indicates that the contribution from the direct deposition on to the food crops is much larger than the contribution from the deposition on the ground.

	SUBMERSION IN THE PLUME		EXPOSURE FROM DEPOSITION					TOTAL
Decay chain	External irradiation	Inhalation	Inhalation resuspension	Inhalation radon	External irradiation	Ingestion food crops	Ingestion milk&meat	
U-238 chain	3,0 E-14	3,9 E-9	4,8 E-12	4,3 E-11	2,2 E-10	3,0 E-8	5,0 E-9	3,9 E-8
Th-232 chain	3,3 E-14	3,9 E-9	5,8 E-12	-	3,1 E-10	3,8 E-9	3,6 E-11	8,0 E-9
TOTAL	**6,2 E-14**	**7,9 E-9**	**1,1 E-11**	**4,3 E-11**	**5,3 E-10**	**3,4 E-8**	**5,0 E-9**	**4,7 E-8**

Comparison between the annual individual effective doses from the decay chains of U-238 and Th-232, to the critical group, after 70 years of operation of the coal-fired power plant. The higher doses from the U-238 decay chain are caused by the large contributions from the ingestion of Pb-210 and especially Po-210 through the food crops.

The total annual dose after 70 years of operation of the power plant (0.05 µSv/y) is well below the exemption level of 10 µSv/y. The normalized values of the dose are up to several orders of magnitude lower than most of them in the literature. The low discharge values and the high NORM content of the fly-ash can be explained by the high efficiency of the gas purification system, reducing the quantity of fly-ash penetrating the system, but also shifting their granulometry towards lower sizes, which are enriched in NORM.

Main contact person

Theo Zeevaert, theo.zeevaert@sckcen.be

Main reference

Th. Zeevaert, L. Sweeck, H. Vanmarcke, "*Radiologische impact op de bevolking na de ingebruikname van een rookgaszuiveringsinstallatie op de site Langerlo te Genk*", studie uitgevoerd in opdracht van Electrabel. SCK•CEN, Mol Belgium, R-3690, 2003.