RADIATION PROTECTION - SELECTED TOPICS
Paper presented at Int. Symposium
Dubrovnik, 2-6 October 1989

ENVIRONMENTAL IMPACT OF NATURAL RADIONUCLIDES FROM THE FOSSIL FUEL POWER PLANTS

Dragoljub Antić
Boris Kidrič Institute of Nuclear Sciences, Vinča
POB 522, Belgrade, Yugoslavia

ABSTRACT

A set of experimental data for selected coals in Yugoslavia is used for this study. The impact of natural radionuclides emited from the coal fired power plants with these coals is analysed. Simple models are used to asses annual doses at the maximum concentration points. The calculated values are compared with the values from the literature for similar calculations.
Keywords: Environmental, Dose eqivalent, Inhalation, Low Level Radiation.

INTRODUCTION

Natural radionuclides are emited from a coal fired power plant because coal contains small quantities of natural radionuclides, such as uranium, thorium, their radioactive daughter products in secular equilibrium and radioactive ^{40}K. They tend to stay with the ash when coal is burned, but yet a part of them are released. The fly ash from burning coal contains such radiotoxic nuclides as ^{226}Ra and large quantities of toxic metals.

The impact of natural radionuclides emited from a coal fired power plant with one of coals (lignites) from Yugoslavia is anlysed. The experimental data, [1], for some coals in Yugoslavia are used for the calculation of annual releases from the power plant.

Because the environmental impact of natural radionuclides vary widely for various factors, such as meteorological conditions and topography, some indications of mean values are given. The passage of natural radionuclides from the power plant through the environment to man is analysed using simple models. A assessment of the annual doses from the inhalation of natural radionuclides at the maximum concentration points is given.

RADIOACTIVE RELEASES FROM A COAL-FIRED POWER PLANT

Release rates of natural radionuclides from a coal fired power plant with power P=1000 MWe and coal consumption $m_c=6,83\cdot10^9$ kg/a are calculated and given in Table 1., [2]. The mean concentration of uranium in coal is taken to be 5,8 ppm, the mean concentration of thorium 8,2 ppm and the mean concentration of ^{40}K, 8000 ppm, [1]. The emission of fly ash is taken to be 1%.

The transport of natural radionuclides from the power plant to maximum concentration points are anlysed using the simple Pasquill model with the difusion coefficients of the diferent systems of diffusion parameters for all stability classes from the literature (Jülich, [3]). For the maximum concentration point (distance 1500 m from the power plant) is the long term dispersion factor assessed as $\chi=1,1\cdot10^{-7}$ s/m^3.

METHODOLOGY OF DOSE ASSESSMENT AND RESULTS

A effective dose equivalent for stochastic effects for an adult was calculated using the relation

$$H_T=H_I+H_S \tag{1}$$

where the total annual effective dose equivalent H_T [μSv/a] from the inhalated radionuclides is calculated as the sume of the commited effective dose equivalent from inhalation of the long-lived radionuclides in one year H_I and the annual effective dose equivalent from inhalation of radon daughters in one year H_S. A dose assessment for 6 long-lived natural radionuclides of the ^{238}U decay chain (^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{210}Pb, ^{210}Po) and radon daughters is given. Effective dose equivalents H_I and H_S are calculated, [4]:

$$H_I=I\cdot\sum_i Q_i\cdot(DCF)_i \tag{2}$$

$$H_S=I\cdot Q_{Rn}\cdot(DCF)_{Rn} \tag{3}$$

where I is the inhalation rate [m^3/a] (0,95 m^3/h for an adult and 0,6 m^3/h for a 10 year old juvenile, [5]);

Q_i is the specific activity of i-th radionuclide in air [Bq/m^3];

$(DCF)_i$ is the dose conversion factor for inhalation of i-th radionuclide [Sv/Bq], [6];

$(DCF)_{RnD}$ is the dose conversion factor for inhalation of radon daughters, [5].

The results of the calculated values of effective dose equivalent from inhalation of the long-lived radionuclides are given in Table 2.

The dose conversion factor for inhalation of radon doughters is taken to be $1,3\cdot10^4$ Sv/a per J/m^3, [4], and 1J/m^3 corresponds to $1,78\cdot10^8$ Bq/m^3 of ^{222}Rn gas in radioactive equilibrium with its short lived doughters. The annual effective dose equivalent from inhalation of radon daughters is calculated H_S= 0,010 μSv/a, and the total annual effective dose equivalent H_T=2,825 μSv/a.

In order to comparate the calculated environmental impact of natural radiounuclides from the coal fired power plants in Yugoslavia with the values from the literature for similar calculations, a dose assessment with dose conversion factors from reference [7] is realized for the same coal fired power plant with release rates given in Table 1. The results are given in Table 3. The dose equivalent from inhalation is calculated from equation (2).

Natural radionuclide		Release rates [GBq/a]	[Bq/s]
^{238}U decay chain	^{222}Rn	48,80	13,60
	$^{218}Po, ^{214}Pb, ^{214}Po, ^{210}Pb, ^{210}Po$	24,40	6,72
	$^{238}U, ^{234}Th, ^{234}Pa, ^{234}U, ^{230}Th$, etc.	4,88	1,36
^{235}U decay chain	^{219}Rn	2,78	0,76
	$^{215}Po, ^{211}Pb, ^{211}Po, ^{207}Pb$	1,12	0,32
	$^{235}U, ^{231}Th, ^{231}Pa, ^{227}Ac$, etc.	0,24	0,08
^{232}Th decay chain	^{220}Rn	182,40	4997,28
	$^{216}Po, ^{212}Pb, ^{212}Po, ^{208}Pb$	9,12	249,84
	$^{232}Th, ^{228}Ra, ^{228}Ac, ^{228}Th$, etc.	1,84	50,02
^{40}K		14,43	448,85

Table 1. Calculated release rates of natural radionuclides from a selected coal-fired power plant (TE "Morava", normalized power 1000 MWe, 1% emission)

Long lived radionuclide	Q_i^* [Bq/m^3]	(DCF)$_i$ [μSv/Bq]	H_{Ii} [μSv/a]	Inhalation class
^{238}U	$1,50 \cdot 10^{-7}$	25,0	0,356	Y
^{234}U	$1,50 \cdot 10^{-7}$	50,0	0,712	Y
^{230}Th	$1,50 \cdot 10^{-7}$	83,3	1,185	W
^{226}Ra	$1,50 \cdot 10^{-7}$	2,5	0,036	W
^{210}Pb	$7,39 \cdot 10^{-7}$	5,0	0,351	D
^{210}Po	$7,39 \cdot 10^{-7}$	2,5	0,175	D=W
H_I for 6 long-lived radionuclides 2,815 μSv/a				

Table 2. Calculated effective dose equivalent from the inhalation of the six long-lived radionuclides of the ^{238}U decay chain in one year

Radionuclide	Release rate Q[Bq/s]	Specific activity $Q\chi$ [Bq/m^3]	Dose equivalent from inhalation [$\mu Sv/a$]
^{238}U	1,36	$1,50 \cdot 10^{-7}$	0,3107
^{234}Th	1,36	$1,50 \cdot 10^{-7}$	0,0120
^{234}Pa	1,36	$1,50 \cdot 10^{-7}$	0
^{234}U	1,36	$1,50 \cdot 10^{-7}$	0,6213
^{230}Th	1,36	$1,50 \cdot 10^{-7}$	3,1036
^{226}Ra	1,36	$1,50 \cdot 10^{-7}$	0,0311
^{222}Rn	13,60	$1,50 \cdot 10^{-6}$	0,0002
^{218}Po	6,72	$7,39 \cdot 10^{-7}$	0,0034
^{214}Pb	6,72	$7,39 \cdot 10^{-7}$	0,0034
^{214}Po	6,72	$7,39 \cdot 10^{-7}$	0,0033
^{210}Pb	6,72	$7,39 \cdot 10^{-7}$	0,3420
^{210}Po	6,72	$7,39 \cdot 10^{-7}$	0,1538
^{210}Bi	1,36	$1,50 \cdot 10^{-7}$	0,0006
^{232}Th	50,02	$5,50 \cdot 10^{-6}$	57,2850
^{228}Ra	50,02	$5,50 \cdot 10^{-6}$	0,0568
^{228}Th	50,02	$5,50 \cdot 10^{-6}$	5,7285
^{228}Ac	50,02	$5,50 \cdot 10^{-6}$	0,0057
^{224}Ra	50,02	$5,50 \cdot 10^{-6}$	0,0380
^{220}Rn	4997,28	$5,50 \cdot 10^{-3}$	0,0001
^{216}Po	249,84	$2,74 \cdot 10^{-4}$	0
^{212}Pb	249,84	$2,74 \cdot 10^{-4}$	0,0400
^{235}U	0,08	$0,88 \cdot 10^{-8}$	0,0171
^{231}Pa	0,08	$0,88 \cdot 10^{-8}$	0,5699
^{227}Ac	0,08	$0,88 \cdot 10^{-8}$	0,1710
^{227}Th	0,08	$0,88 \cdot 10^{-8}$	0,0034
^{223}Ra	0,08	$0,88 \cdot 10^{-8}$	0,0011
Total dose equivalent from inhalation			68,5039

Table 3. Dose equivalent from inhalation of natural radionuclides from a coal-fired power plant (releases from Table 1., h_{stack}=100 m, distance 1500 m, long term dispersion factor $1,1 \cdot 10^{-7}$ s/m^3).

The calculated dose equivalent from inhalation is greated than the results from reference [7], because the relatively large quantities of uranium, thorium and ^{40}K in the lignites in Yugoslavia.

CONCLUSION

A assessment of the radiation exposure of the public from a selected coal-fired power plant in Yugoslavia is given. The calculated dose equivalent from literature, because the large quantities of natural radionuclides (uranium, thorium, their radioactive daughter products and ^{40}K) in selected lignite.

REFERENCES

[1] P. R. Adžić et al.: Fizika, 14(1), p.1-5(1982)

[2] D. Antić: Proc. of Jahrestagung-Kerntechnik '89, p.687-690, Düsseldorf (1989)

[3] J. E. Till, H. R. Meyer: "Radiological Assessment". NUREG/CR-3332, ORNL-5968, Washington, 1983

[4] Safety Series No. 90, IAEA, Vienna, 1989.

[5] ICRP Publication 23(1975)

[6] ICRP Publication 30(1984) Statement from the 1983 Washington Meeting of the ICRP. Annals of the ICRP, 14(1)

[7] V. Ferrara, Notiziario dell' ENEA - Energia e inovazione, 32(11-12), p.96-107(1986).