RADIOACTIVE POLLUTING POTENTIAL OF COAL-FIRED POWER PLANTS FROM ROMANIA

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ABSTRACT

Between 1993-1995,26 coal-fired power plants(CFP) were investigated.Water,coal,filter fly-ash,disposed ash and bottom-ash(slag) samples were collected.All samples were analysed for their natural radioactive element content (^{238}U and ^{232}Th series,and K-40) and at the sampling points the gamma dose rates were measured.

The escaping fly-ash, produced ash(fly-ash and slag) and the coal consumption per GWa were assessed as the associated activities of radionuclides.The mass radon flux density for coal,filter fly-ash,disposed ash,and slag samples were measured on lab specimens as well as the surface radon flux density for same building materials with ash content and were assessed the effective anual doses due to living is houses constructed with such materials.

INTRODUCTION

Coal is burned in furnaces operating at up to 1,800^{0}C in order to produce thermal and electrical energy,requiring $3 \cdot 10^9$ kg of coal to produce 1GWa of electrical energy (1).In the UNSCEAR 1982 Report (2) it is estimated the average concentration of ^{40}K,^{238}U and ^{232}Th in coal to be 50,20,20 Bq kg^{-1}, respectively.In a more recent paper from China (3) these concentrations are appreciably higher:104,36 and 30 Bq kg^{-1} for the same radionuclides.

Owing mainly to the elimination of the organic content of the coal,there is about an order of magnitude enhancement of the concentrations from coal to ash.So,the natural radionuclide concentrations in ash and slag from CFPs are signifinatly higher than the corresponding concentrations in earth's crust.Arithmetic averages in escaping fly-ash are 265 Bq kg^{-1},200 Bq kg^{-1},240 Bq kg^{-1} and 70 Bq kg^{-1} for ^{40}K,^{238}U,^{226}Ra and ^{232}Th,respectively (2).

METHODOLOGY

For estimation of radioactive pollutig potential of CFPs water(raw,industrial,recirculating),coal,filter (collected) fly-ash,slag and disposed ash samples were collected.The comsumption,produced ash and escaping fly-ash per GWa were assessed as well as the associated activities of radionuclides.

All samples were analysed for their radionuclide content using radiochemical or gamma spectrometric methods,respectively thermal neutron activation associated with gamma ray spectrometry for ^{238}U.

At the sampling points the gamma dose rates were measured using portable gamma rate meters having a sensivity of 0.01μSvh^{-1}(1μSv=100μR).

RESULTS AND DISSCUTION

All waters used in CFPs had U nat and ^{226}Ra concentations under the limits for drinking water(0.021 mg Unat/dm^3,0,088 Bq ^{226}Ra/dm^3(4),by themselves being not a radioactive pollution source.

The arithmetic averages of radionuclide contents of the 43 coal samples(bitumonous coal,lignite,brown coal) were at the level of reported averages in coal,being 36.3 Bq kg^{-1} for ^{238}U(range:6-112),44.4 Bq kg^{-1} for ^{226}Ra (range:2-112),19.7 Bq kg^{-1} for ^{232}Th(range:1-44) and 267 Bq kg^{-1} for ^{40}K(range:30-500).The mean ash content of coals varied between 20 and 62% and the caloric power between 1,200 and 5,500 Kcal kg^{-1}.

The activity concentrations of natural radionuclides of residual materials from CFPs are shown in Table 1.

It can be seen, than the highest activity concentrations were found in collected fly-ask and these value were taken into account for the computation of radioactive pollution potential by escaping fly-ash, although it is this know that the activity concentrations in this fraction are higher (2).

Using laboratory experiments(5) the mass radon flux density (Em) of coal, collected fly-ash, slag and disposed ash samples was measured.The results of these experiments are shown in Table 2.

The highest values for Em were measured for coal samples and the lowest ones for slag samples.

Also, were estimated the annual coal consumption, produced ash and atmospheric discharge by escaping fly-ash per GWa of electic energy generated by 19 CFPs which have had produced electric energy.The results of these estimates are shown in Table 3.

Activity concentrations of natural radionuclides in residual materals from CFPs

Table 1

ASH (no of sample)		Activity concentration ($Bq\ kg^{-1}$) ^{238}U	^{226}Ra	^{232}Th	^{40}K
Collected fly-ash	Average	100.0	129.3	49.6	421
(27)	Range	25-223	50-221	3-86	96-885
Disposed ash	Average	88.6	107.7	41.9	403
(27)	Range	17-230	21-227	5-86	83-1,097
Slag	Average	68.5	79.0	33.7	317
(20)	Range	6-161	15-159	3-84	71-852

Mass radon flux density (Em) vs. nature of sample

Table 2.

Nature of sample	No. of samples	Em ($10^{-8}\ Bq\ g^{-1}s^{-1}$) Average	Range
Coal	42	3.45	0.56 - 12.13
Collected fly-ash	26	1.59	0.11 - 4.70
Disposed ash	27	1.18	0.43 - 2.59
Slag	20	0.26	0.03 - 0.82

Estimates of annual coal consumption,ash production and atmospheric discharge per unit electrical energy generated

Table 3.

CFPs	Total installed power		Coal consumption $10^9\ kg(GWa)^{-1}$		Normalized Ash production $10^9\ kg(GWa)^{-1}$	Escaping fly-ash $10^6\ kg(GWa)^{-1}$	
19	GW						
Modern[a]	8.64	Range	4.5 - 20.4	(6)	1.56 - 8.16	4.5 - 304	(6)
		Average	11.73	3	4.33	64.2	7

a) Equipped with electrofilters

Using the values of activity concentrations of collected fly-ashes and the amounts of atmospheric discharges were assessed the activities of normalized discharges.The results of these estimates are shown in Table 4.

Estimates of the activities of annual atmospheric discharges per unit energy generated (GBq/GWa)

Table 4.

CFPs	Fly-ash removal efficiency %		^{238}U	^{226}Ra	^{232}Th	^{40}K
Modern	95 - 99.8	Average	8.4	10.0	3.65	32.2
(19)		Range	0.3-33.1	0.5-36.4	0.14-19.1	1.3-127.1

The total amount of disposed ash from ash dumps(from 26 CFPs) was estimated as being $230 \cdot 10^6$ t, and the total activity of natural radionuclides from these ones as being 21 TBq for ^{238}U, 29TBq for ^{226}Ra, 11TBq for ^{232}Th and 83 Tbq for ^{40}K and the activity of radon gas emanated in a year as being 93 TBq.

The gamma background in coal-fired power stations ranged between 0.04 and 0.12 $\mu Sv\ h^{-1}$, sometimes being slighty enhanced in comparison to the natural background of the areas.On the ash dumps the gamma dose rates ranged between 0.07 and 0.25 $\mu Sv\ h^{-1}$ being 2-3 times higher than the gamma background of the vicinities.

Two building materials with ash content in comparison with a normal one were investigated.The activity concentrations of natural radionuclides of these materials are shown in Table 5.

Activity concentrations of natural radionuclides in some building materials

Table 5.

Building material (ash content %)	^{226}Ra Bq kg^{-1}	^{232}Th Bq kg^{-1}	^{40}K Bq kg^{-1}	Density kg m^{-3}
Building material 1 (70)	123	52	141	660
Building material 2 (38)	40	13	52	1,780
Building matreial 3 (0)	27	11	242	660

Using laboratory specimens the surface radon flux density (E) was measured and were calculated the external, internal and total effective doses for a reference room build up from each material used 100%, the ventilation rate 1, residence time 4380h/y, equilibrum coefficient 0.4, conversion factor of equivalent equilibrum radon concentration in effective dose (mSv h^{-1} per Bq m^{-3}) of 9nSv and Ackers' conversion factors (6) .The results of these measurements and computation are shown in Table 6.

Annual effective dose due to bulding materials

Table 6.

Building material (ash content %)	E Bq m^{-2} h^{-1}	Annual effective dose (mSv) External	Internal	Total
Building material 1 (70)	1.14	0.397	0.024	0.421
Building material 2 (38)	0.62	0.119	0.013	0.132
Building material 3 (0)	0.80	0.118	0.017	0.135

It can be seen from Table 6 that the major contribution to the total effective dose is given by the external effective dose.At the same time, it is evident that in certain conditions building materials can be used without an additional risk for the public.

CONCLUSIONS

The main conclusions that resulted from this research are:

Coal-fired power plants are a potential radioactive polluting source for the environment due to atmospheric discharges of escaping fly-ash as well as by the presence of ash dumps, the activity concentrations of natural radionuclides in ashes being higher than in earth's crust.

Building materials with coal ash content can be used, in certain conditions, without additional risk for the public.

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