

Potassium from Coals and its Contribution to Their Radioactivity

MARILENA BUGARU*

Politehnica University of Bucharest,

The emitted radiation problem of the natural radionuclides represents an important study of what it means the prevention and the control of the environmental pollution. The research deals with the distribution of the radionuclide $^{40}_{19}\text{K}$ in coals and in ashes resulted by their burning. Series of mineral coals, in different stages of carbonizations, of Romania's main regions, have been studied. The researches performed lead to the conclusion that in the material extracted from mine with approximate 30% sterile, the radionuclide $^{40}_{19}\text{K}$ is placed at 50–60 ppm level and in ashes at 150–180 ppm. The researches show that in the case of coals, even at an approximate 30% content of ashes, the radioactive pollution is not too risky. It would be useful that, from exploitation, the coals could be extracted from thick layers with a reduced content of associated minerals. Among the minerals associated to the coals, the clays represent the main factor of concentration of $^{40}_{19}\text{K}$ element. The biggest content of clays from lignites is the element which enriches the coal extracted in potassium and also in its isotopes. The ashes resulted from the burning of coals have contents of 150–180 ppm in $^{40}_{19}\text{K}$ a very important aspect for their utilisation or depositing. The study attempts to resolve some aspects linked to the problems of the coal radioactivity and also of ashes resulted by it's burning.

Keywords: coals, radionuclides in coals, potassium, ashes, radioactive pollution

Often in the past, for the study of one material, the radionuclides of the actinides were discussed, but in this writing we try to point out a few elements considered in the past as being inoffensive concerning the radioactivity of the coals. Among these elements, potassium the element considered to be useful and not linked to the problems of radioactive pollution, is the main element which causes the radioactive impurity of the coals by it's radionuclide $^{40}_{19}\text{K}$.

In the table 1 the main minerals know in nature with potassium content are presented, but with the specification of the fact that the first four minerals can be also found in a great extent in coals.

The study of the table shows that in this kind of minerals the potassium content represents 6–52%, from which the $^{40}_{19}\text{K}$ radioactive isotope represents 0,012%. In coals with a content of 30% ashes, which correspond to a sterile content of approximate 40%, a big quantity from sterile may be represented by minerals with potassium content.

The abundance of the potassium in nature, the content in radioactive isotopes and their characteristics are presented in table 2.

The study of the table shows that in comparison with known radionuclides with concentrations up to 10–15 ppm in coals, the radionuclide $^{40}_{19}\text{K}$ represents tens and sometimes hundreds of ppm in coals and in ashes resulted of their burning which justify the studies of this paper.

Table 1
THE MAIN MINERALS WITH POTASSIUM KNOWN IN NATURE

MINERAL	APPROXIMATED FORMULA	POTASSIUM %	% $^{40}_{19}\text{K}$
MUSCOVITE	$\text{KAl}_2[(\text{HO}, \text{F})_2\text{AlSi}_3\text{O}_{10}]$	8.94	0.08
BIOTITE	$\text{K}(\text{Mg}, \text{Fe})_3[(\text{HO}, \text{F})_2\text{AlSi}_3\text{O}_{10}]$	6.27	0.062
SYLVITE	KCl	52.34	0.52
POTASH FELDSPAR ORTHOCLASE	$\text{K}[\text{AlSi}_3\text{O}_8]$	14.02	0.14
SYLVINITE	KCl·NaCl	29.32	0.29
CARNALITE	$\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	14.05	0.14
CAINITE	$\text{KCl} \cdot \text{MgSO}_4 \cdot 3\text{H}_2\text{O}$	15.69	0.15
SCHÖNITE	$\text{K}_2\text{SO}_4 \cdot \text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	9.7	0.09
POLIHALITE	$\text{K}_2\text{SO}_4 \cdot \text{MgSO}_4 \cdot 2\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	6.47	0.06
CALINITE	$\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$	8.22	0.08
LEUCITE	$\text{K}[\text{AlSi}_2\text{O}_6]$	17.88	0.17
ALUNITE	$\text{KAl}_3(\text{SO}_4)_2 \cdot (\text{OH})_6$	9.42	0.09

* Tel.: (+40) 021 7763957

Table 2
CHARACTERISTICS OF THE $^{40}_{19}\text{K}$ RADIONUCLIDE

Characteristics	UNITS	VALUES
NATURAL ABUNDANCE OF THE ELEMENT UPON CLARKE	%	2.4
CONTENT OF $^{40}_{19}\text{K}$ 'S ISOTOPE IN THE NATURAL MIXTURE OF ISOTOPES	%	0.012
ATOMIC WEIGHT OF THE NATURAL MIXTURE OF ISOTOPES OF THE POTASSIUM ELEMENT	u.a.m.	39.102
TIME OF DIVIDING OF THE $^{40}_{19}\text{K}$ ELEMENT	ANI	$1.28 \cdot 10^9$
TYPE OF DESINTEGRATION FOR $^{40}_{19}\text{K}$ ELEMENT		β^- , β^+ , EC, γ
ENERGY OF DESINTEGRATION OF THE $^{40}_{19}\text{K}$ ISOTOPE	MeV	1.35 1.505 1.460

The reserches were performed by analyse according to the norms ISO and Romanian standards fitted for the characterization of the coals and their rank, but also for the determination of the potassium content existing in the extract rock and in the ashes resulted by it's burning.

From analytical data concerning the distribution in nature of the $^{40}_{19}\text{K}$ isotope it was calculated it's concentration in coals and in ashes resulted by it's burning.

Results and discussions

Series of coals in different stages of carbonizations were analysed to know the distribution of $^{40}_{19}\text{K}$ isotope, starting with lignite of Schitu Golești and to petroleum oligocene pitcoals of Lupeni.

The tehcnical and elementary analysis of the coals is presented in table 3.

The content of coals and of ashes resulted by their burning in potassium and in radionuclide $^{40}_{19}\text{K}$ is presented in table 4.

The study of the table and of the figure shows that in coals the content of potassium and in the $^{40}_{19}\text{K}$ radionuclide is not dependent on the degree of carbonization. It is determined from the associated minerals of coals and it is situated at approximate 0.60%, what leads to approximate 60 ppm from the $^{40}_{19}\text{K}$ radionuclide.

The fact that in ashes the potassium content is 1-2% and the $^{40}_{19}\text{K}$ radionuclide of 150-180 ppm, shows that this element is in stable combinations, usually clays, which are all transformed in ashes.

Table 3
CHARACTERISTICS OF THE COALS

COAL	RANK	WATER	ASHES	VOLATILE MATTER	CARBON	HYDROGEN	OXYGEN +NITROGEN
		W^a	A^{anh}	V^{mc}	C^{mc}	H^{mc}	$O^{mc}+N^{mc}$
		%	%	%	%	%	%
SCHITU GOLEȘTI	LIGNITE	14.21	32.12	55.21	65.32	5.83	28.85
ȘORECANI	BROWN COAL	4.15	30.21	50.16	69.37	5.34	25.39
LONEA	BITUMINOUS COAL (OLIGOCENE)	3.10	33.53	47.22	75.31	5.03	19.66
PETRILA	BITUMINOUS COAL (OLIGOCENE)	2.11	32.41	45.34	77.32	5.00	17.68
DĂLJA	BITUMINOUS COAL (OLIGOCENE)	2.04	35.16	44.28	16.28	4.94	6.94
ANINOASA	BITUMINOUS COAL (OLIGOCENE)	2.31	34.12	43.12	78.77	4.85	16.28
LUPENI	GAS COAL (OLIGOCENE)	1.950	32.82	40.23	79.32	4.78	15.90

Table 4
 CONTENT OF POTASSIUM IN ROMANIAN COALS, IN DIFERENT RANKS
 AND IN ASHES RESULTED FROM THEIR BURNING

COAL	POTASSIUM CONTENT		CONTENT OF $^{40}_{19}K$		CONTENT OF $^{40}_{19}K$	
	COAL	ASHES	COAL	ASHES	COAL	ASHES
	%	%	%	%	ppm	ppm
SCHITU GOLEȘTI	0.63	1.82	0.006	0.018	60	180
ȘORECANI	0.60	1.71	0.006	0.017	60	171
LONEA	0.55	1.63	0.005	0.016	50	163
PETRILA	0.58	1.61	0.006	0.016	60	161
DĂLJA	0.56	1.62	0.006	0.016	60	162
ANINOASA	0.57	1.50	0.006	0.016	60	158
LUPENI	0.52	1.52	0.005	0.015	50	152

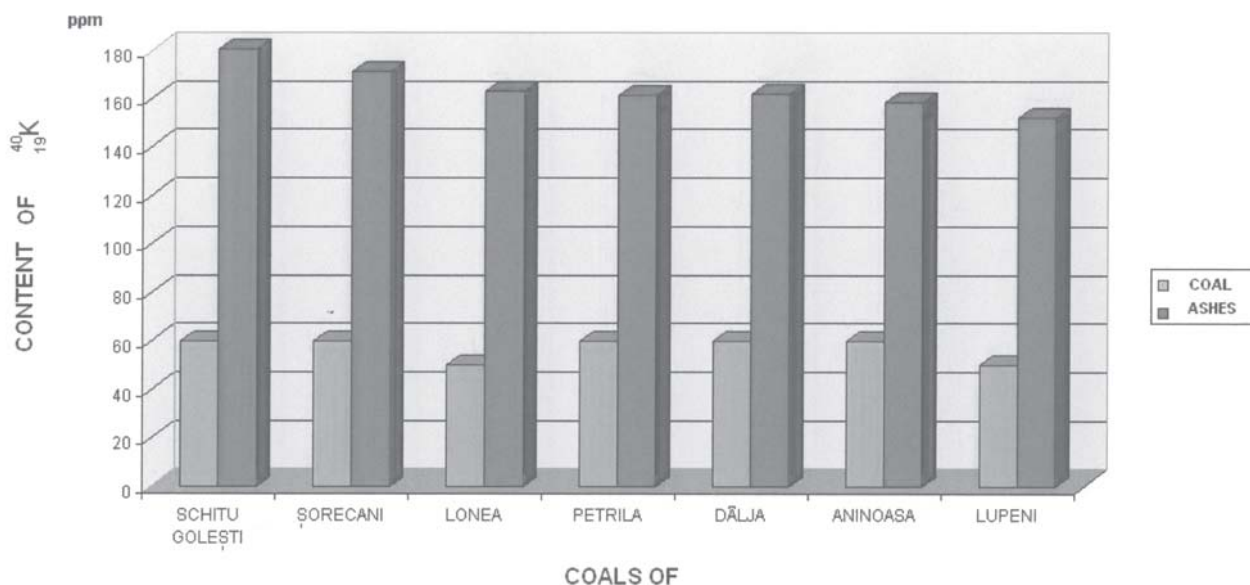


Fig. 1. Variation of the $^{40}_{19}K$'s content in the raw coals, in different ranks of carbonization

Conclusions

The main element which induces the impurity with radionuclides of the coals, is the potassium, by his $^{40}_{19}K$ isotope.

Potassium is not an element linked to the organic mass of the coals. It is introduced in coals by the associated minerals, for that the ashes concentrate approximate 1-2% potassium, respective 150-180 ppm $^{40}_{19}K$.

The content of $^{40}_{19}K$ isotope in ashes creates radioactive emissions which are placed at the superior and admissible limit.

The effect of the radioactive emissions β^- , β^+ , is annihilated by the environment at small distances from the place of transmission.

The γ radiations is active at small distances which involves the covering of the waste heap of ashes with layer of protecting soil.

The usage of ashes in the civil constructions industry, mainly residences, must be restricted so that they should not exceed the value admissible radiations.

It is indicated that the coals exploitation to be made with a smaller content of associated minerals, reducing thus the chemical and also the radioactive pollution.

Bibliography

1. BARCA F., PENCEA I, Elemente de radioactivitate, tehnică și ecologie nucleară specifică caustobiolitelor. (București) Ed. Printeh 1999, p. 119
2. FLUES M., MORAES V., Environ Radioact, **63**, nr 3, 2002, p. 285
3. KARANGELOS D.J., PETOPOULOS N.P., Environ Radiact, **77**, nr. 3, 2004, p. 233
4. STUPARU LUMINIȚA, Rev. Chim (București), **60**, nr.7, 2007, p. 135

Manuscript received: 29.09.2008