The collective dose equivalent in evaluated region of bone-coal power stations and bone-coal shafts

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Abstract During 1991-1993, the radioactivity levels of the bone-coal mines were investigated in Hubei, Hunan, Jiangxi, Zhejiang and Anhui Provinces, respectively, where the reserve of bone-coal is about 90% of our country's total reserve. The annual additional collective dose equivalent within 80km evaluated region of bone-coal power stations in Nijiangkou and Anren is 1.7 and 1.9 man·mSv, respectively, and that of Zhuantanyan bone-coal shaft is 1.4 man·mSv. The collective dose equivalent caused by bone-coal cinder brick produced for 25 years in the five provinces is 1.6×10^5 man·Sv.

Key words Dose, Bone-coal, Bone-coal power station, Environment

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1 Introduction

The reserve of bone-coal in Hubei, Hunan, Jiangxi, Zhejiang and Anhui Provinces accounts for about 90% of total reserve in China. More than two hundred years ago, local people spontaneously started to mine the bone-coal on a small scale. At present, the bone-coal is not only used to make lime and then the lime used as a building material or to improve the soil, but also used as a kind of fuel for generating electricity. However, the chimney' exhaust of the bone-coal power station will increase the radioactive contamination in surroundings. This is a man-made radioactivity, which will lead to possible increase of public dose in these regions.

In 1991, the National Environment Protection Agency and the Safety Protection Bureau of the Chinese Nuclear Industry Corporation granted a project named "the study of effect of mining and utilizing radioactivity-associated bone-coal on environment". The investigation items include γ radiation doserate, natural radionuclides, content of non-radioactive elements, concentration of ^{222}Rn, evaluation and estimation of the dose equivalent. Lasting more than two years, the project was completed in 1993. The estimation of collective dose equivalent, which is caused by bone-coal power station, bone-coal shaft, bone coal

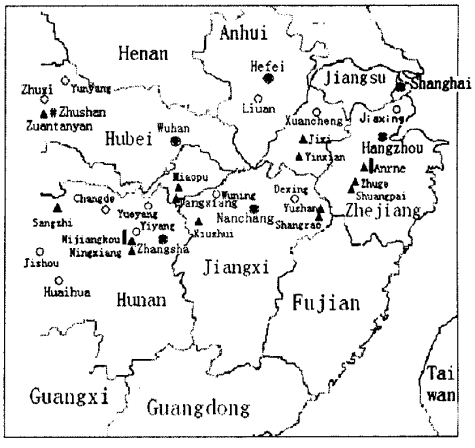

Fig.1 Distribution of bone-coal mines in five provinces.
| Bone-coal power station; # Bone-coal shaft;
▲ Investigated point; ● Provincial capital.

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cinder bricks (BCCB, commonly also called "carbide brick") with richer natural radioactive radionuclides, is one of important subprojects in this investigation. The distribution of bone-coal mines in five provinces is shown in Fig.1. The capacity, evaluated region, population distribution of Nijiangkou Bone-Coal Power Station (NJK-BCPS) in Hunan Province, Anren Bone-Coal Power Station (AR-BCPS) in Zhejiang Province and Zhuantanyan Bone-Coal Shaft (ZTY-BCS) in Hubei Province are shown in Table 1 and Figs. 2-4.

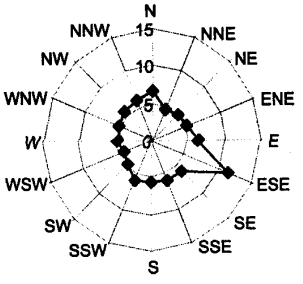

Fig.2 Population distribution map within 80km evaluated region for NJK-BCPS (10^{-2} million/p).

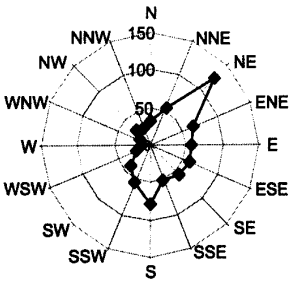

Fig.3 Population distribution map within 80km evaluated region for AR-BCPS (10^{-2} million/p).

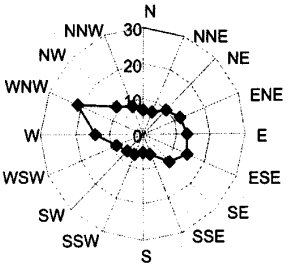

Fig.4 Population distribution map within 80km evaluated region for ZTY-BCS (10^{-2} million/p).

Table 1 Capacity and population of the evaluated region of bone-coal power stations and shafts

Provinces	Locality	Kind	Annual capacity (kW)	Evaluated region	Population(million)
Hunan	Nijiangkou	Power station	5600	Yiyang, Ningxiang, Hanshou, Xinhua, etc.	9.04
Zhejiang	Anren	Power station	750	Jiande, Tonglu, Fuyang, Shaoxing, Lin'an, etc.	7.62
Hubei	Zhuantanyan	Shaft		Zhushan, Zhuxi, Baokang, Yun, etc. and Shenlongjia Forest	1.59

2 Dose estimation method and measuring instruments

In this investigation, the adopted measurement methods and the lower levels of detection (LLD) of instruments are listed in Table 2.

The China Research Institute of Radiation Protection has estimated the collective annual additional effective dose equivalent of 192 subareas in the evaluated regions of bone-coal power stations and bone-coal shafts, according to the released quantity of gas passing through BCPS's chimneys and the specific activity of radionuclides in the dust from exhaust orifice of BCPS's chimneys, the released quantity of radon from (or the radon concentration in) exhaust orifice of bone-coal shafts. And the local meteorological data over years, the unified parameters of residents' recipes, residence factors, conversion coefficients of dose and other related parameters were also considered. The estimating results of collective dose equivalent are listed in Table 3.

Table 2 Details of measurement methods

	Items	Methods	Frequency	Instruments	LLD
Gas	^{222}Rn concentration	Track etch method	2-4/a	CSR detector	3.0 Bq/m^3
BCCB house	γ radiation	Scintillation method	2-4/a	SG-102 X-γ doserate meter	10 nGy/h
Dust of chimney	radionuclides	γ spectrometry	2-4/a	HPGe γ spectrometer	

Table 3 The collective dose equivalent in evaluated regions of BCPS

Locality	The highest individual dose equivalent (μSv/a)								Collective dose (man·Sv/a)
	Direction	Subarea	Critical group		Critical radionuclide		Critical way		
			Group	Dose	Radionuclide	Dose	Way	Dose	
NJK-BCPS	SSW	First		27	^{210}Pb		Ingest		1.7
AR-BCPS	WSW	First	Juvenile	62	^{226}Ra	29	Ingest	34	1.9
ZTY-BCS	E-SSE	First	Infant, juvenile	28	^{222}Rn		Inhalation		1.4

3 Results of dose estimation

3.1 Bone-coal power station

From Table 3, the highest individual annual additional effective dose equivalent is 27μSv in the first subarea located in SSW direction of NJK-BCPS, because of natural radionuclides such as ^{238}U, ^{226}Ra, ^{232}Th, ^{40}K, ^{210}Po, etc. in dust released from chimney, with the critical radionuclide of ^{210}Pb, the critical way of ingest, and the annual collective dose equivalent of 1.7 man·Sv within 80km evaluated region of the NJK-BCPS.

The highest individual annual additional effective dose equivalent caused by ^{226}Ra, ^{232}Th, ^{40}K and ^{210}Po released from the chimney is 62μSv in the first subarea located in WSW direction of AR-BCPS. The critical residential group is juvenile group. The critical radionuclide is ^{226}Ra which contributes 29μSv. Ingest is the critical way which brings about 34μSv. The collective annual additional effective dose equivalent is 1.9 man·Sv within 80km evaluated region of the AR-BCPS.

3.2 Bone-coal shaft

From Table 3, it is known that the highest individual annual additional effective dose equivalent caused only by the radon released from ZTY-BCS is the first subarea located in E, ESE, SE and SSE directions within 80km evaluated region. The individual dose equivalent of critical groups of infant and juvenile is 28μSv, the critical way is inhalation. The collective dose equivalent is 1.4 man·Sv within 80km evaluated region of ZTY-BCS.

3.3 Carbide bricks

The collective dose equivalent caused by bone-coal cinder brick (BCCB) houses was estimated according to the dose estimation formulas provided by the UNSCEAR report (1982,1993),[1,2] the total output of the carbide brick for 25 years in the five provinces, 50 year's duration of living in these houses, and the dose equivalent for the residents living in the BCCB houses.[3] The estimated results are listed in Table 4.

Table 4 Collective dose equivalent attributed to the production of BCCB

Provinces	Annual output ($\times10^6$ps)	Total output for 25 years ($\times10^6$ps)	Number of residents ($\times10^6$)	Individual annual additional dose equivalent (internal and external irradiation, mSv)[1)]	Collective annual additional dose equivalent (man·Sv)	Collective dose (man·Sv)
Hubei	95.25	2380	0.419	3.1	1299	6.40×10^4
Hunan	113	2830	0.497	3.2	1590	8.15×10^4
Jiangxi	5.0	125	0.022	1.9	41.8	2.12×10^3
Zhejiang	2.5	62.5	0.011	6.8	74.8	3.76×10^3
Anhui	4.0	108	0.018	4.0	72	3.71×10^3
Sum	219.75	5500	0.967	19.0	3078	1.6×10^5

1) Quoted from Ref. [3]

Table 4 shows that the collective additional effective dose equivalent for the residents living in BCCB houses of Hubei, Hunan, Jiangxi, Zhejiang and Anhui Provinces is 6.40×10^4, 8.15×10^4, 2.12×10^3, 3.76×10^3 and 3.71×10^4 man·Sv, respectively. The total collective dose equivalent for the five provinces is about 1.6×10^5 man·Sv.

4 Conclusions

(1) It is desirable to select a kind of fine boiler

system, suitable dust remover[4] for reducing the effect of bone-coal power station on the environment. If a wet-dust remover or electrostatic precipitator is used, the precipitating efficiency will be enhanced, the dust released from chimney will decrease obviously, and the highest individual dose and collective dose within the 80 km evaluated region for BCPS will be reduced effectively.

(2) When the bone-coal cinder with high contents of natural radionuclides from BCPS is used as mixture material to produce cement or other building materials, it is crucial to not exceed the "Limit of Radionuclides in Building Materials" (GB 6566-2001). [5]

(3) The best way to decrease the radon concentration in bone-coal shaft and the total collective dose equivalent within 80km evaluated region of the shaft is to strengthen the ventilation of bone-coal shaft. And miners' self-protection consciousness and knowledge of radiation protection should be enhanced. Various rules and regulations about radiation safety must be observed.

(4) The BCCB houses surpassing standard limit of γ-ray dose rates or radon concentration cannot be used as dwelling of residents in order to prevent public from undue radioactive irradiation.

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