ELSEVIER

Journal of
Environmental Radioactivity 62 (2002) 115–119

JOURNAL OF
ENVIRONMENTAL
RADIOACTIVITY

www.elsevier.com/locate/jenvrad

Evaluation of ^{210}Pb and ^{210}Po in cigarette tobacco produced in Brazil

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Received 22 February 2001; received in revised form 10 August 2001; accepted 29 August 2001

Abstract

Cigarette smoking is one of the pathways that might contribute significantly to the increase in the radiation dose reaching man, due to the relatively large concentrations of ^{210}Pb and ^{210}Po found in tobacco leaves. In the present study, the concentrations of these two radionuclides were determined in eight of the most frequently sold cigarette brands produced in Brazil. ^{210}Pb was determined by counting the beta activity of ^{210}Bi with a gas flow proportional detector after radiochemical separation and precipitation of $PbCrO_4$. ^{210}Po was determined by alpha spectrometry using a surface barrier detector after radiochemical separation and spontaneous deposition of Po on a copper disk. The results showed concentrations ranging from 11.9 to 30.2 mBq per gram of dry tobacco for ^{210}Pb and from 10.9 to 27.4 mBq per gram of dry tobacco for ^{210}Po. The collective committed effective dose resulting from the use of cigarettes produced in Brazil per year is estimated to be 1.5×10^4 man-Sv.

Keywords: Tobacco; Natural radioactivity; Radiochemistry; Collective dose

1. Introduction

It is well known that natural radioactivity is a major source of worldwide human exposure to ionizing radiation, a fraction of which results from anthrophogenic activities not subject to regulatory radiological safety standards. Due to the presence of

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0265-931X/02/$ - see front matter
PII: S0265-931X(01)00146-1

natural radionuclides of the uranium and thorium series in fresh tobacco leaves, in an amount exceeding that normally found in general foods for human usage, cigarette smoking is one of these practices of radiological concern (Kilthau, 1996).

Among the several poisonous chemicals found in cigarettes, ^{210}Po is the major radioactive element of interest because it can be inhaled with cigarette smoke, due to its low volatilization temperature. ^{210}Pb is another element of interest since it is ^{210}Po precursor in the radioactive decay chain and because of the characteristics of the processes of cigarette production.

A review of the radioactivity levels in cigarettes consumed worldwide reported by Watson (1983) showed that ^{210}Po concentration ranged from 6.7 to 31.1 mBq per gram of dry sample. A later study showed a relatively low concentration of ^{210}Po in cigarettes from Syria, ranging from 0.74 to 2.96 mBq per gram of dry sample (Batarekh & Teherani, 1987).

The present investigation is part of a study that seeks to add information to the database related to natural radioactivity in Brazil, and to motivate the discussion on the legislative aspects of the commercial use of consumer products containing amounts of natural radionuclides artificially enhanced by man. In this note the activity concentrations of ^{210}Pb and ^{210}Po found in major brands of the cigarettes produced in Brazil are presented.

2. Materials and methods

Eight of the most frequently sold Brazilian brands of cigarettes, representing $>$75% of the total national market (Souza Cruz, 2001) were analyzed in the present study. Although each brand has several types of cigarettes, only the most popular one was chosen for analysis. For each brand of cigarette two samples were acquired randomly on the market, at different places and time (with the exception of brand D, for which four samples were acquired). For each sample, the content of three packages was homogenized together and 15 g of the mixture used for ^{210}Pb determination and another 15 g for ^{210}Po analyses. The analysis were carried out in triplicate.

For ^{210}Pb determination, 5 g of tobacco were leached with nitric acid, followed by successive precipitation of $Ba(Ra,Pb)SO_4$, PbS and $PbCrO_4$ basically according to the procedures described by Nevissi (1991) and Colangelo, Huguet, Palacios, and Oliveira (1992) and Moreira (1993). ^{210}Pb was determined by beta counting of ^{210}Bi grown in the final precipitate using a low background gas flow proportional counter (Berthold LB770-2). The counting efficiency was determined using a standard solution of ^{210}Pb prepared and measured according to the same methodology as adopted for the tobacco sample. The value obtained was about 35% for each detector. The chemical yield of the process was 61–98% and the minimum detectable concentration (95% confidence level) of this method was 4.5 mBq g^{-1} with a counting time of 400 min.

For ^{210}Po determination, ^{208}Po tracer was added to 5 g of tobacco. The sample was leached with nitric acid, followed by tributylphosphate (TBP) extraction and spontaneous deposition of polonium on a copper disc (Raya, 1995; Nieri Neto, 1996;

Saito, 1996). The alpha spectrum was obtained by counting with a surface barrier detector (EG&G ORTEC 576A). The counting efficiency was determined using an electrodeposited source of ^{241}Am and the value obtained was 0.125±0.001. The chemical yield of the process was 23–67% and the minimum detectable concentration of this method (95% confidence level) was 5×10^{-5} mBq g^{-1} with a counting time of 1000 min.

A measurement of the reproducibility of the method presented a coefficient of variation of 9.4 and 10.4% for ^{210}Pb and ^{210}Po, respectively. The accuracy was checked with a standard ^{210}Pb solid matrix from IAEA and the measured values for ^{210}Pb and ^{210}Po lay within the certified value range, at a 95% confidence level (Peres, 1999).

3. Results and discussion

^{210}Pb concentrations ranged from 11.9 to 30.2 mBq per gram of dry tobacco, with an arithmetic mean of 21.3 mBq g^{-1} and standard deviation of 4.1 mBq g^{-1}, while ^{210}Po concentrations ranged from 10.9 to 27.4 mBq g^{-1}, with an arithmetic mean of 21.2 mBq g^{-1} and standard deviation of 3.7 mBq g^{-1} (Table 1). The activity concen-

Table 1
Activity concentration ^{210}Pb and ^{210}Po in Brazilian cigarette tobacco[a]

	Activity concentration (mBq per g dry wt)[b]	
Brand	^{210}Pb	^{210}Po
A	22.6±3.7	20.9±3.3
	23.6±2.9	19.3±0.8
B	27.8±0.2	25.2±3.1
	30.2±2.2	27.4±3.9
C	20.0±1.9	22.9±1.9
	23.3±3.9	22.0±2.7
D	11.9±2.1	10.9±2.2
	23.8±1.6	20.7±0.1
	[c]	23.5±0.4
	22.8±6.0	19.9±3.4
E	20.1±4.6	23.3±0.3
	15.8±1.2	[c]
F	20.7±3.6	19.2±3.4
	19.6±3.0	26.2±2.2
G	18.7±2.2	20.5±0.8
	20.4±3.6	19.6±2.8
H	20.4±2.6	18.8±5.3
	20.2±3.7	21.6±0.6

[a] The mean mass of the cigarettes analyzed was (0.73±0.03) g per cigarette.
[b] ±SD.
[c] Not determined.

tration of ^{210}Pb and ^{210}Po that we found in Brazilian cigarettes are within the range reported in the literature. Lopes dos Santos, Weinberg, and Penna-Franca (1970) and Azeredo (1988) reported ^{210}Po concentration of about 17 mBq per gram of tobacco and Godoy, Gouvea, Mello, and Azeredo (1992) reported a concentration ranging from 10.6 to 26.8 mBq g^{-1}. Considering the measurement precision of each analysis, radioactive equilibrium was observed between the two radionuclides, an expected result since the time elapsed between the harvest of tobacco leaves and the placement of cigarettes on the market is sufficient for ^{210}Po to increase until it reaches radioactive equilibrium with ^{210}Pb.

Assuming that the mean concentrations obtained in the present study are representative of the cigarettes produced in Brazil in general, we can estimate the collective and mean individual committed effective doses. Assuming that an individual smokes 20 cigarettes per day, and that 10% of the Pb and 20% of the Po are inhaled by primary smokers (UNSCEAR, 1982) and by applying the dose coefficients for adults of 5.6×10^{-6} Sv Bq^{-1} for ^{210}Pb and 4.3×10^{-6} Sv Bq^{-1} for ^{210}Po (ICRP72, 1995) the committed effective dose is estimated to be 0.16 mSv per year of cigarette smoking. Considering an annual production of 5×10^{8} kg of cigarettes in Brazil (AFUBRA, 1999), the collective committed effective dose resulting from the use of cigarettes corresponding to one year of production is estimated to be 1.5×10^{4} man-Sv. Although this is a rough estimate of the collective dose, it indicates that cigarette smoking could be a considerable portion of the global dose resulting from avoidable exposure to natural radioactivity.

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