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# Investigation and Evaluation of Polonium-210 Content in Tobacco

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## Abstract

Abstract: China is a major tobacco consumption country, with smokers trending toward younger ages. As tobacco leaves contain various natural radionuclides, smoking increases the internal radiation dose to the human body. This paper analyzes the 210Po levels in 36 domestic cigarette brands and 4 foreign cigarette brands. The results show that the 210Po content in domestic cigarettes ranges from (22.4~50.1) mBq/g (or 13.1~32.1mBq per cigarette), with a mean value of 35.3mBq/g (or 21.7mBq per cigarette); the 210Po content in foreign cigarettes ranges from (18.5~24.3mBq/g) (or 11.1~12.7mBq per cigarette), with a mean value of 21.2mBq/g (or 12.1mBq per cigarette). Overall, the 210Po content in domestic cigarettes is slightly higher than that in foreign cigarettes. Based on the 210Po content in tobacco, the estimated daily intake of 210Po by smokers in China is approximately (26.7~161.5mBq)/day, resulting in an internal radiation dose equivalent to human lung tissue of (32.1~194.5) Sv/a.

## Full Text

## Exploration and Evaluation of Polonium-210 Content in Tobacco

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### Abstract

China is a major tobacco consumer with a progressively decreasing age of initiation. Since tobacco leaves contain various natural radionuclides, smoking increases the internal radiation dose to the human body. This study analyzed 210Po levels in 36 domestic and 4 foreign cigarette brands. Results showed that domestic cigarettes contained 210Po ranging from (22.4~50.1) mBq/g

(or 13.1~32.1 mBq per cigarette), averaging 35.3 mBq/g (or 21.7 mBq per cigarette). Foreign cigarettes ranged from (18.5~24.3) mBq/g (or 11.1~12.7 mBq per cigarette), averaging 21.2 mBq/g (or 12.1 mBq per cigarette). Overall, domestic cigarettes exhibited slightly higher 210Po content than foreign brands. Based on these levels, Chinese smokers inhale approximately (26.7~161.5) mBq of 210Po daily from cigarettes, resulting in an internal radiation dose equivalent of (32.1~194.5) Sv/a to lung tissue.

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According to relevant studies [**?**], tobacco smoke contains at least over 1,000 harmful components, including various natural radioactive nuclides. The concentration of radioactive nuclides in tobacco is more than 100 times higher than that in general crops, particularly polonium-210, lead-210, and radium-226 [**?**]. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reported that polonium-210 and lead-210 in tobacco are the primary sources of alpha radiation (internal exposure) to humans, with polonium-210 accounting for 7% of the total effective dose from natural internal radiation [**?**]. For smokers consuming one and a half packs of cigarettes daily, the annual radiation exposure from smoking is equivalent to undergoing 300 chest X-rays.

The radioactivity in cigarettes and its health hazards have gradually attracted public attention. However, domestic research on the radioactivity levels in tobacco and the resulting internal radiation dose to human lung tissue remains limited. This study analyzes and compares 36 domestic and 4 foreign commercially available cigarette brands to investigate the 210Po content in cigarettes and estimate the internal radiation dose to Chinese smokers, providing a preliminary assessment.

## Materials and Methods

**1.1.1 Reagents** Reagents included ascorbic acid, hydrazine hydrochloride, concentrated nitric acid, concentrated hydrochloric acid, etc. Unless otherwise specified, all analytical reagents met national standards for analytical purity, and laboratory water was deionized water.

**1.1.2 Silver Discs** Circular silver discs ($ $22 mm, thickness 0.6 mm) were used. Prior to use, one side of each disc was coated with acid- and heat-resistant

paint, while the other side was polished with sandpaper, rinsed with clean water, and air-dried.

**1.1.3 209Po Tracer** A 209Po tracer produced by Eckert&Ziegler (Germany) was diluted to prepare a secondary standard solution.

**1.1.4 Standard Source** A standard source of 241Am/239+240Pu produced by the National Institute of Metrology, China, was used for instrument calibration.

**1.1.5 Alpha Spectrometer** The measurement instrument was an alpha spectrometer manufactured by ORTEC (USA), with a detection efficiency for 241Am greater than 25% and a background count rate of less than 1 cps/h. The instrument was regularly calibrated and remained within its valid calibration period during measurements.

### 1.3 Analysis Procedure

(1) Randomly select five cigarettes from each brand, place them in an oven, and dry at low temperature to constant weight.

(2) Remove the tobacco shreds from the cigarettes, weigh them, place them in a beaker, and add 1 ml of 209Po standard solution as a tracer.

(3) Add 30 ml of concentrated nitric acid to the beaker, cover with a watch glass, and digest overnight without heating. After complete dissolution of solids, heat on an electric hotplate at 130°C until dense yellow fumes cease. Add a certain amount of hydrogen peroxide solution for further digestion, and evaporate to dryness once the solution becomes clear.

(4) Add a small amount of perchloric acid, ensure thorough wetting, and evaporate to dryness at 120°C.

(5) Add 20 ml of 2 mol/L hydrochloric acid solution to the dried beaker, extract at low temperature for 30 minutes, filter into a 100 ml Erlenmeyer flask, rinse the beaker with 60 ml of deionized water, and combine the filtrates.

(6) Add 2 g of ascorbic acid and 1 g of hydroxylamine hydrochloride to the Erlenmeyer flask, dissolve completely, then place the silver disc in the flask with the polished side facing up. Seal the flask with rubber film to prevent volume change.

(7) Place the Erlenmeyer flask in a constant-temperature water bath oscillator for 1 hour of deposition at 95°C. After deposition, remove the silver

disc, rinse sequentially with anhydrous ethanol and distilled water, dry in an oven at 105°C for 1 hour, then remove and cool.

(8) Place the silver disc on the alpha spectrometer for 48 hours of measurement.

**1.4 Sample Calculation** The 210Po content in samples was calculated using the following formula: ·····(2)
Where in equations (1) and (2):
C210—activity concentration of 210Po in the sample, Bq/g or Bq/cigarette;
A209—amount of 209Po tracer added, Bq;
N210—210Po count;
N209—209Po count;
m—mass of tobacco shreds, g;
s—number of cigarettes.

## Results and Discussion

**2.1 Analysis of Polonium-210 Content in Cigarettes** Experimental analysis results of polonium-210 activity levels in cigarette tobacco are presented in Table 1 and Figure 1 [Figure 1: see original paper]. As shown in Table 1 , the 210Po content in 36 domestic cigarette brands ranged from 13.1~32.1 mBq per cigarette and 22.4~50.1 mBq/g, with average values of 21.7 mBq per cigarette and 35.3 mBq/g. Among these, Changsha cigarettes exhibited the highest 210Po content at 32.1 mBq per cigarette and 50.1 mBq/g. No clear correlation was found between 210Po content levels and cigarette type (flue-cured, blended, or cigar) or tar content.

Table 1 also reveals a relationship between cigarette grade and 210Po content: low-grade cigarettes (such as Huangshan, Zhongnanhai, etc.) contained less 210Po than medium- and high-grade cigarettes (such as Suyan, Zhonghua, etc.). This may be because medium- and high-grade cigarettes use more tender tobacco leaves, while low-grade cigarettes predominantly utilize coarse leaves, mature leaves, and stems. According to relevant research [**?**], 210Po content in tobacco leaves is significantly higher than in stems. Although tobacco leaves account for approximately 50% of the plant' s weight, they contain about 87.1% of the plant' s total 210Po, with approximately 66% of 210Po residing in mature leaves.

In this study, five different types of cigarettes were selected as parallel samples for testing, including four domestic brands and one international brand. Relative deviation was calculated according to the formula specified in the Technical Specifications for Radiation Environmental Monitoring (HJ 61-2021) [**?**]: relative deviation = |(Data 1 - Data 2) / (Data 1 + Data 2)|. This technical specification stipulates that the relative deviation for parallel polonium samples in water and aerosols must not exceed 20%, though no specific requirement is established for biological samples. In this cigarette sample test, the maximum relative deviation for parallel samples was 8.34% and the minimum was 1.85%,

both meeting the criteria for conventional parallel sample testing and demonstrating high accuracy in the 210Po measurement results. These results are summarized in Table 2 .

As shown in Table 3 , 210Po content in cigarettes varies slightly among countries. Based on the data presented in this paper and relevant literature, the 210Po content in cigarettes from highest to lowest is: China, United Kingdom, Japan, and United States. Comparison with research by Wang Xin, Zhao Lancai, and others reveals no significant change in 210Po content in domestic cigarettes across the 1990s, 2000s, and 2020s. This indicates that despite the considerable time span, 210Po content in Chinese cigarettes has remained relatively stable without a clear downward trend.

**2.2 Dose Estimation for Inhaled 210Po to Human Lung Tissue** According to ICRP 1995 [**?**], the behavior type of 210Po under smoking conditions is classified as M (moderate), which characterizes the transfer rate of radionuclides from the lungs to blood and other human tissues. Based on the M-type classification in ICRP 2012, the 210Po dose coefficient is 3.3$×$10ˆ-6 Sv/Bq. Chinese smokers were categorized as light, moderate, and heavy smokers, consuming 10, 20, and 40 cigarettes per day, respectively. Using the average 210Po content of 21.7 mBq per cigarette, the estimated doses are presented in Table 4 .

## Conclusions

1. The 210Po content in Chinese cigarette tobacco ranges from 13.1~32.1 mBq per cigarette or 22.4~50.1 mBq/g, with mean values of 21.7 mBq per cigarette and 35.3 mBq/g. Changsha cigarettes exhibited the highest 210Po content at 32.1 mBq per cigarette and 50.1 mBq/g, while Zhongnanhai cigarettes showed the lowest at 13.1 mBq per cigarette and 22.3 mBq/g. Foreign cigarette brands contained 210Po ranging from 11.1~12.7 mBq per cigarette or 18.5~24.3 mBq/g, averaging 12.1 mBq per cigarette or 21.2 mBq/g. The 210Po level in domestic cigarettes is approximately twice that of other countries.
2. The higher 210Po content in Chinese cigarettes may be attributed to elevated background levels of uranium-238 decay products in tobacco-growing soils and the enrichment effect from phosphate fertilizer use. For moderate smokers in China consuming 20 cigarettes daily, with a smoke inhalation fraction of 15.7%, the daily intake is calculated as 68.14 mBq. Using Beijing as an example, where the airborne 210Po activity concentration is 0.81 mBq/mˆ3 [**?**], an adult male inhales approximately 10 mˆ3 of air daily. Referring to Publication 71 and literature [**?**], with an estimated inhalation deposition efficiency of 40%, the daily 210Po intake from air is 3.24 mBq. Therefore, smokers inhale approximately 20 times more 210Po daily than non-smokers. If the normal daily 210Po intake is 180

mBq as reported in literature [**?**], smoking increases daily 210Po intake by approximately 37.86%.

3. Based on Table 4 , the radiation dose from smoking accounts for 1.34%~8.10% of the annual natural background radiation exposure for Chinese residents (2.4 mSv), making it the third-largest artificial radiation source after medical exposure. This finding emphasizes the additional radiation risk that smoking poses to human health, particularly in regions or populations with high smoking prevalence. Therefore, beyond the direct effects on cardiovascular and respiratory health, the radioactive exposure from smoking warrants serious attention. While such studies are common internationally, domestic research remains scarce. It is recommended that young and middle-aged researchers continue to investigate the sources of 210Po in cigarettes, explore its relationship with its parent nuclide 210Pb, and deepen our understanding of dose levels to human lung tissue from 210Po intake.

## References

[1] Kou Rongchun. Polonium-210 in cigarettes and lung cancer[J]. Environmental Science, 1990(05):70-74+97.DOI:10.13227/j.hjkx.1990.05.020.
[2] Wang Wenbin. Radionuclides in soils, fertilizers, and tobacco leaves from Yunnan tobacco-growing areas[D]. Southwest Agricultural University, 2002.
[3] Charles M. UNSCEAR report 2000: sources and effects of ionizing radiation[J]. Journal of Radiological Protection, 2001, 21(1): 83
[4] Wang Chunhong, Wu Zhao, Liu Senlin, et al. Radiation levels in cigarettes and doses to smokers[J]. Chinese Journal of Radiological Health, 2021, 30(04): 442-447.DOI:10.13491/j.issn.1004-714X.2021.04.011.
[5] Ministry of Ecology and Environment. Technical Specifications for Radiation Environmental Monitoring: HJ 61—2021[S]. Beijing: China Environment Publishing Group, 2021.
[6] Wang Xin, Chen Xing' an, Pan Yingdong. Study on 210Po content in cigarettes and its dose to human lung tissue[J]. Chinese Journal of Radiological Health, 2000, (03):129-133.DOI:10.13491/j.cnki.issn.1004-714x.2000.03.001.
[7] Zhao Lancai, Yamamoto Masayoshi, Chen Yingmin, et al. Determination of lead-210 and polonium-210 in 40 cigarette brands from China, Japan, and other countries[J]. Chinese Journal of Public Health, 1990, (05):257-260.
[8] Eckerman K, Harrison J, Menzel H, et al. ICRP Publication 119: Compendium of Dose Coefficients based on ICRP Publication 60[J]. Annals of the ICRP, 2013, 42(4):e1-e130.
[9] Zhao Qingqing, Cong Shu, Fan Jing, et al. Analysis of smoking status among Chinese adults aged 40 years and above in 2019-2020[J]. Chinese Journal of Epidemiology, 2023, 44(5):735-742.
[10] Pan Jingshun, Wen Fuping, Chen Ling, et al. Preliminary analysis of 210Po and 210Pb activity concentrations in air of major Chinese cities[J]. Radiation Protection, 2017, 37(06):433-437.

[11] Pan Yuxi, Li Junli, Liu Weirong, et al. Study on estimation method for internal dose from inhaled 210Pb[J]. Atomic Energy Science and Technology, 2014, 48(01):152-157.
[12] Ionizing Radiation: Levels and Effects[R], Volume I: Levels. Beijing: Atomic Energy Press, 1978.

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