Natural radioactivity evaluation and radiological safety of worldwide tea brands

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Tea stands as one of the most widely enjoyed beverages globally. Given the escalating environmental pollution with toxic substances such as pesticides, metals, and radioactivity, it is crucial to conduct monitoring studies on the presence of radionuclides in the environment. Especially when the EU Council Regulation 2016/52/Euratom systematized the emergency limits on radionuclides in foods, including ^{210}Po, the most critical radionuclides from the ingestion pathway. This study widely presents the content of radiotoxic radionuclides – the alpha emitter ^{210}Po and the beta emitter ^{210}Pb in 141 different tea brands collected from 18 countries worldwide. The effective annual radiation doses and cancer risk resulting from consuming tea infusions were also calculated based on the measured activity concentrations. The research findings and outcomes highlight that consuming the investigated teas is safe from a radiological perspective.

To estimate the activity concentrations of ^{210}Po and ^{210}Pb, we 141 chose various types of tea from 18 countries from four continents: Argentina (samples nr 36-39; 48-50), Brazil (43), China (88-141), Columbia (26-27), Ecuador (45), Georgia (46-47), India 73-87(), Japan (1-18), Kenya (29), Korea (51-54), Mozambique (23-25), Nepal (40-42), Rwanda (30), South Africa (31-35; 69-72), Sri Lanka (55-68), Taiwan (19-22), Tanzania (28), and Vietnam (44).

The concentrations of ^{210}Po activity among all 141 samples of analyzed teas ranged from 1.64±0.09 Bq·kg^{-1} in green tea from Columbia (Valle de Cauca), up to 59.5±1.60 Bq·kg^{-1} also in green tea but from China (Zhejiang). Similarly to ^{210}Po, the highest concentration of ^{210}Pb activity was observed in green tea from China (Jiangxi), at 72.2±2.74 Bq·kg^{-1}, while the lowest in the leaves of the rooibos plant (*Aspalathus linearis*) from South Africa (Cedarberg), which ranged 0.46±0.04 Bq·kg^{-1}. All ^{210}Po and ^{210}Pb activity concentration values in examined teas are presented in Figures 1 and 2. The highest annual effective radiation dose from ^{210}Po ingestion with maximum extraction efficiency tea infusion was calculated for two green teas sourced from China, namely from Zhejiang province (sample 90 and 92 – 39 μSv·year^{-1} and 31.3 μSv·year^{-1}, respectively) and for green tea from Japan (Shizuoka) equal to 34.2 μSv·year^{-1}. In the same group, the lowest effective doses (1.08, 1.14, 1.15, and 1.18 μSv·year^{-1}) were calculated for tea from Columbia (green tea; sample 27), Argentina (lapacho; sample 36 and 37) and China (black tea; sample 121), respectively (Fig. 3). For annual effective radiation doses from the decay of ^{210}Pb, the highest values were also calculated for tea infusion consumption at 5% and 30% extraction efficiency from green tea from China, amounting to 4.54 and 27.3 μSv·year^{-1}, respectively. On the other hand, the lowest doses were associated with the consumption of rooibos tea from South Africa, valued at 0.03 and 0.17 μSv·year^{-1} for 5% and 30% extraction, respectively (Fig. 4).

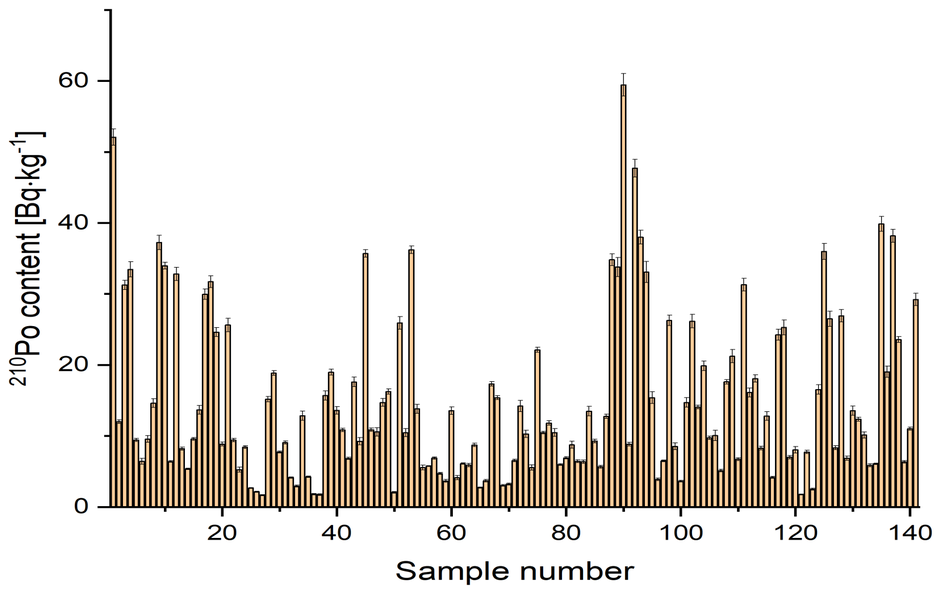

Fig. 1 ^{210}Po concentration in analyzed teas

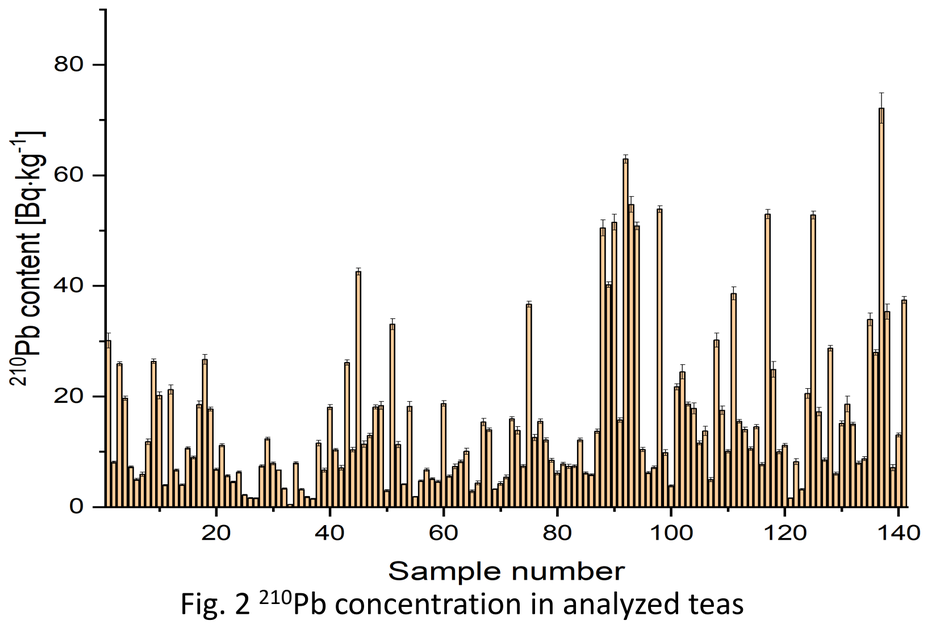

Fig. 2 ^{210}Pb concentration in analyzed teas

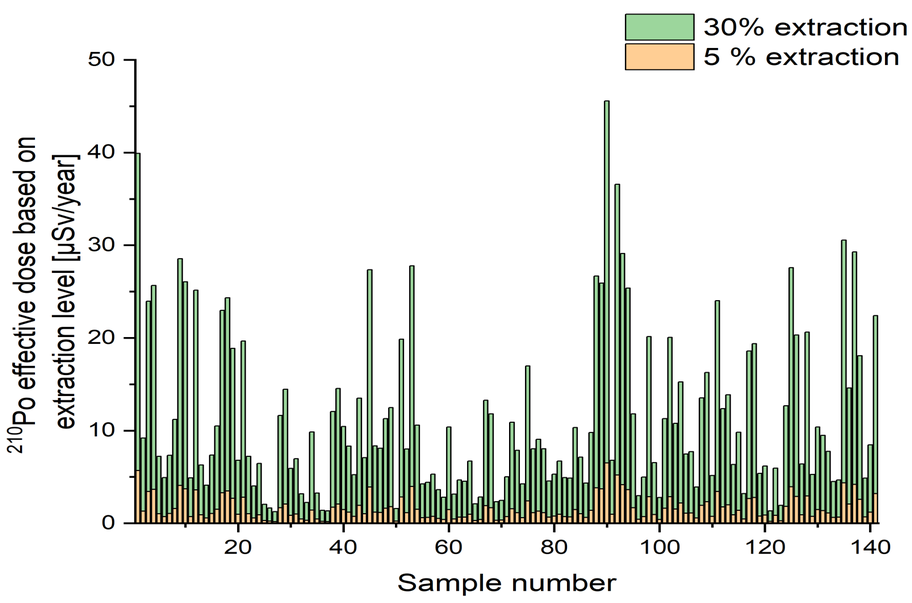

Fig. 3 The annual effective radiation doses from ^{210}Po decay taken with teas

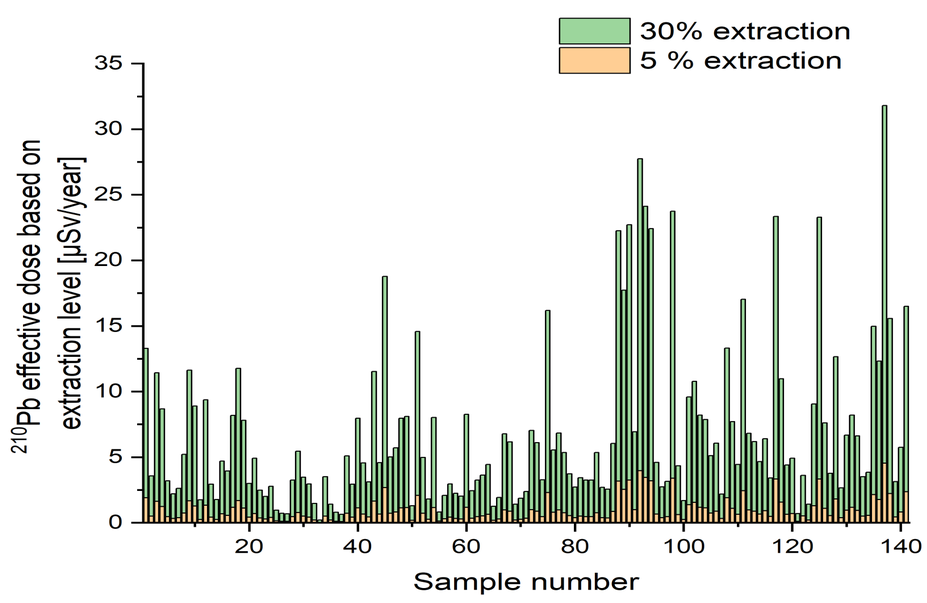

Fig. 4 The annual effective radiation doses from ^{210}Po decay taken with teas

Investigating 141 different tea brands, we identified the presence of radiotoxic nuclides – ^{210}Po and ^{210}Pb. However, the concentrations obtained and the subsequently calculated annual radiation doses resulting from the consumption of tea infusions do not pose a threat from a radiological perspective. It is crucial to note that despite the radiological safety of each product, excessive consumption of any item may present different risks to the human body. Furthermore, based on our statistical and chemometric analysis, numerous unknowns persist regarding the correlation between the content of both radionuclides and factors such as the tea's growing region. Future research should explore tea production, geological substrate, and other relevant factors. Expanding our investigations in these directions will contribute to unraveling the complexities of radionuclide presence in tea, promoting a more comprehensive understanding of potential variations associated with geographical origins. This information is vital for ensuring the continued safety of tea consumption and guiding responsible agricultural practices in tea-producing regions.