International Joint Conference Radio 2022

Th-232 Radiological Aspects of Carbonate Niobium Mining Waste Use as Agricultural Amendment

Ayllon, R. M[a]., Furlan[b] M. R., El Hajj, T. M[c]., Silva[a] P. S. C.

[a] IPEN – Instituto de Pesquisas Energéticas e Nucleares, (IPEN/CNEN-SP), Av. Prof. Lineu Prestes, 2242. CEP 05508-000. São Paulo. SP. Brazil.

[b] Universidade de Taubaté (UNITAU – SP), Rua Quatro de Março, 432, 12020-270, São Paulo, SP, Brazil

[c] Universidade Federal de Alfenas (UNIFAL-MG), Rodovia José Aurélio Vilela, 11999, Poços de Caldas, Brazil

pscsilva@ipen.br

Introduction

Brazil is the world leader in the ferroniobium production, accounting for more than 90% of world production. This metal is widely used in superalloys, superconducting magnets and in medical and jewelry applications [1]. Due to the geological association between niobium ore and Naturally Occurring Radioactive Material (NORM) and the large amounts of waste produced, the later constitute an economic and ecological burden if not properly disposed of or re-used [2]. In this sense, the wasteless concept has gained more and more importance [3]. Earlier measurements made in this residue showed that the ^{232}Th activity concentrations found in it has mean value of 1,141 Bq kg^{-1}, reaching up to 5,056 Bq kg^{-1}, depending on the lithological domain [4]. In this research it was proposed the use of the material named carbonate concentrate, produced as tailings in the early stages of the niobium production, as soil amendment.

Methodology

To verify the radiological implications of using the niobium carbonate waste as soil amendment, lettuce was cultivated in four different treatments and two harvesting: a) soil, b) soil + lime, c) soil + carbonate and d) soil + lime + carbonate. In the treatments b and c, 3 kg of lime or carbonate was added to 1 m^3 of soil. In the treatment d 1.5 kg of lime and 1.5 kg of carbonate was added to 1 m^3 of soil. In each treatment the substrate and lettuce was analyzed by neutron activation analysis (INAA) for Th determination. All samples were dried, crushed and packed in polyethylene bags. Reference materials were used for concentration determination by the comparative INAA method.

Results

Thorium activity concentration in the carbonate niobium waste presented mean value of 652 ± 61 mg kg^{-1} and in soil with no addition of any amendment (treatment a), the Th concentration was 37 ± 2 mg kg^{-1}. The substrates used in treatments b, c, and d, Th concentrations were 30.7 ± 0.3, 44 ± 2 and 36 ± 7, respectively. The concentration of Th obtained in the lettuce samples for the different treatments are shown in table 1. It can be observed that the lowest concentration was found in soil without amendment addition. In the treatment using lime, carbonate or the mixture of the two no significant difference can be observed. It was reported that vegetables consumed in a high background radiation area in Brazil presented mean value of ^{232}Th concentration 0.002 mg kg^{-1}. This value is two orders of magnitude lower than the ones reported here.

Considering an ingestion of 2 g day^{-1}of lettuce and the mean values presented in table 1, the effective dose, in this case, varies from 0.09 to 0.3 μSv y^{-1}.

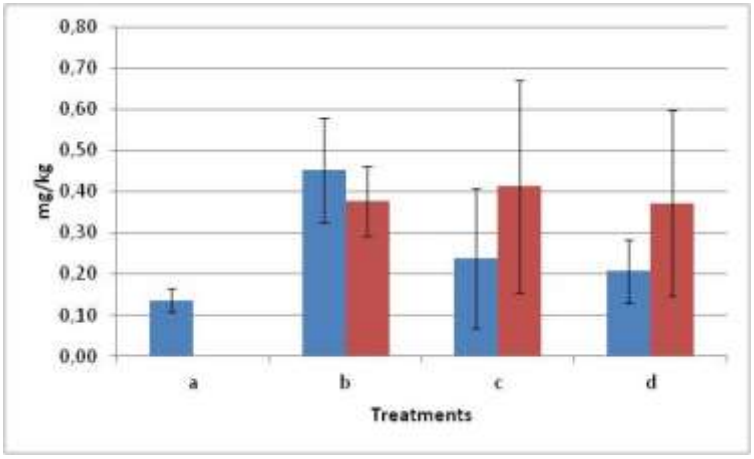

Figure 1: Thorium concentration in lettuce cultivated in a) soil without treatment, b) soil + lime, c) soil + carbonate and d) soil + lime + carbonate. In blue, first harvesting and in red, second harvesting.

Conclusions

The use of amendment in the soil for lettuce cultivation can favor the ^{232}Th absorption, nevertheless, the use of carbonate residue from niobium mining activity do not resulted in higher absorption than the commonly lime regularly used. The effective dose resulting from the lettuce ingestion varied from 0.09 to 0.3 µSv y^{-1}.

References

1. Lima, L. S., Alvarenga, R. A. F., Amaral, T. S., Nolli, P. T. G., Dewulf, J., 2022. Life cycle assessment of ferroniobium and niobium oxides: Quantifying the reduction of environmental impacts as a result of production process improvements, Journal of Cleaner Production, 348, 131327.
2. Josef Maringer, F., Baumgartner, A., Cardellini, F., Cassette, P., Crespo, T., Dean, J., ...Vodenik, B., 2017. Advancements in NORM metrology – results and impact of the
European joint research MetroNORM. Applied Radiation and Isotopes, 126, 273–278.
3. Palacios, L. T., Rodríguez, J. A. E., 2022. In mining, not everything is a circular economy: Case studies from recent mining projects in Iberia, Resources Policy, 78, 102798.
4. T. M. El Hajj, M. P. A. Gandolla, P. S. C. Silva, H. Torquato, H. Delboni, 2019. Long-term prediction of non-processed waste radioactivity of a niobium mine in Brazil, Journal of Sustainable Mining, 18(3), 142-149.
5. Rosa, M. M. L., Maihara, V. A., Taddei, M. H. T., Cheberle, L. T. V., Avegliano, R. P. Silva, P. S. C., 2022. The use of total diet study for determination of natural radionuclides in foods of a high background radiation area, Journal of Environmental Radioactivity, 242, 106793.