1st International & 28th National Conference on Nuclear Science & Technology 2022 (ICNST22)
Nuclear Science & Technology Research Institute

Phytoremediation and Investigation of uranium uptake by Amaranthus Tricolor

Hoseinpour H[1], Zolghadri S[2*], Yousefnia H[2], Nabipour A[3], Aghayan H[4], Khoshnoodi K[4], Kakaei S[2], Rabiee Samani T[1]

[1]Esfahan Nuclear center (ENTC)-Fatsa company, B. O. Box: 81465-1589, Tehran, Iran.
[2]Radiation Application Research School, Nuclear science and technology Research Institute, P.O.BOX: 14893-836, Tehran, Iran.
[3]Agricultural, Medical and Industrial Research School, Nuclear Science & Technology Research Institute, P.O. Box: 31485-498, Karaj, Iran.
[4]Nuclear fuel cycle Research School, Nuclear science and technology Research Institute, P.O.BOX: 14893-**836**, Tehran, Iran.

[*] *Email: szolghadri@aeoi.org.ir*

Abstract

In this study, the ability of amaranthus tricolor to adsorb uranium from the sandy soil was studied. The soil was polluted with 300 mg/Kg of uranium. The amounts of uranium in different parts of plant were investigated using the ash method after 30 days. More than 1200 mg/Kg of uranium was adsorbed in the roots, but only a small amounts of uranium was transferred to the upper parts. The transfer factor for stem and leaf was determined as 0.09 and 0.06 respectively. The data showed that Amaranthus Tricolor can adsorb uranium from the soil, however, more studies are still needed to determine the effects of other parametrs in uranium adsorption.

Keywords: Phytoremediation, Uranium, Amaranthus Tricolor

Introduction

The phytoremediation is a process in which the plants are used to extract, isolate and eliminate contaminants in the soil and climate [1]. This technique utilizes the natural ability of plants to absorb and accumulate metals and radionuclides. Amaranthus tricolor is an annual plant with a height of 1-3 meters. Murata et al. [2] and Brownell and Billig [3] reported that the plant family Amaranthaceae, to which Amaranth belongs, is one of three plant families that are naturally neutrophilic. Amaranthus tricolor has been reported to germinate at a concentration of 250 mM sodium chloride (EC ~ 25 dS m^{-1}) [4]. This study was aimed to investigate the ability of Amaranthus tricolor to absorb uranium from the sandy soil.

Experimental

The sandy soil was selected for planting while the characteristics of soil was examined using the ASTM standard method (ASTM D4972, ASTM D1125, ASTM D7263-21, ASTM D422-63, ASTM D7503 and ASTM D2974). The soil was contaminated with 300 mg/Kg of uranium. For this purpose , uanium nitrate was dissolved in distilled water and sprayed on the soil surface. In order to stabilize and balance the soil and the metal components and to assimilate the artificial pollution conditions with the natural pollution conditions, the contaminated soil was placed in the free air for 2 weeks.

Amaranthus Tricolor was planted in the pots filled with 3.150 kg of the mentioned soil, 63 g of manure, 0.63 g of urea and 0.4 g of ammonium phosphate. The pots were irrigated twice a week. The plants were harvested after 30 days. Then different organs of the plant (leaves, stems and roots) were isolated. The samples were dried in an oven at a temperature of 80 ° C and for 80 hours while weighed by a digital scale.

The samples were digested using the ash method. The furnace temperature was gradually raised to 500 ° C for 2 hours and the samples were kept at this temperature for 5 to 6 hours. Then 10 ml of 65% nitric acid was added to each sample and the samples were transferred to 50 ml Erlenmeyer flask. The samples were placed in an oil bath on a heater at 120 ° C. The amount of uranium in each sample was determined utilizing ICP-OES spectrometer.

Results and discussion

The characteristics of the soil is presented in Table 1. The texture of the soil is clay-sandy loam. Soil texture is medium and water holding capacity in soil is low. The soil is calcareous with a high percentage of lime and its pH is alkaline.

The main minerals in the soil characterized by XRD analysis are calcite $CaCO_3$ and quartz SiO_2, respectively. Denmorite and Hein ferroglacop may be present in small amounts. The results of XRF analysis

show that the main oxides of soil include CaO, SiO_2, Fe_2O_3 and Al_2O_3.
The amount of uranium absorbed in different parts of plant is indicated in Figure 1. The data indicated that however considerable amounts of uranium (more than 1000 mg/Kg) accumulated in the root, but low content was transferred to the upper parts of the plant (stem and leaf).

Table 1. The characteristics of the soil used for planting.

SP	EC(ds/m)	pH	%TNV	%OM	texture
28.0	13.41	7.88	51.19	1.27	S.C.L

Transfer factor which defined as the uranium concentration in the plant to the uranium concentration in the soil is also calculated. The values are determined as 0.09, 0.06 for leaf and stem, respectively.

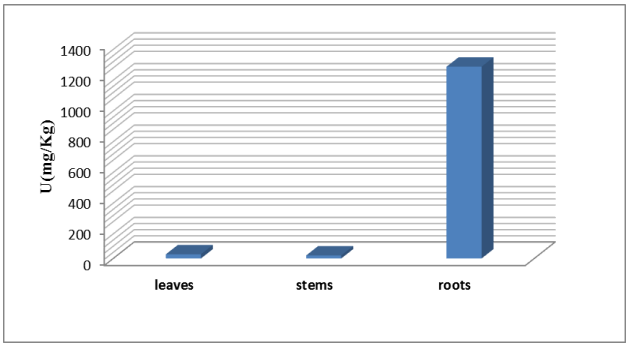

Figure 1. The amounts of uranium (mg/Kg) in different parts of Amaranthus Tricolor.

While sunflower and Indian mustard are known as the uranium hyperaccumulator plants, sunflower is a relatively sensitive plant to soil salinity. The yield of this plant at EC = 6 dS / m is reduced to 50% . Therfore, planting of sunflower in regions with sandy soils can not lead to a promising result. But according to a new study on different genotypes of Indian mustard in loamy sandy soil with EC equal to 12 dS / m, RB-10 and PR-2004-2 genotypes are known as tolerant species [6].
In this section, the transfer factor is compared with the values provided by Chang et al. [5]. It should be noted that the reason for comparison with this study is the more similarity to the other previous works. For example, the initial concentrations of uranium in soil and soil texture are almost identical. The uranium transport factor values for Indian mustard and Brassica napus in the study of Chang et al is given in Table 2.

Table 2. Transfer factor of Indian mustard and Brassica napus [5].

Plant	Plant organ	Transfer Factor
Indian Mustard	stem	1.02
Brassica napus	stem	0.06
	leaf	0.02

As it can be seen, the transfer factor of stem and leaf for Amaranthus Tricolor achieved in this study is higher than these amounts for Brassica napus while it is lower than the values for Indian mustard [5].

Conclusions

Amaranthus tricolor can absorb considerable amounts of uranium in its root while low accumulation was observed in the upper parts. In comparison to brassica napus and Indian mustard, it adsorbed more and less uranium in its leaves and stems, respectively. it is stongly suggested to assess the effects of other parameters including the time of harvesting, fertilizer, the amounts of irrigation and so on the uranium adsorption of amaranthus Tricolor.

References

[1] A. Yan, Y. Wang, S.N. Tan, et al. Phytoremediation: *A Promising Approach for Revegetation of Heavy Metal-Polluted Land.* Front Plant Sci. 11, 359 (2020)

[2] S. Murata, M. Kobayashi, T. Matoh, et al. *Sodium stimulates regeneration of phosphoenolpyruvate in mesophyll chloroplasts of A. tricolor*. Plant Cell Physiol. 33, 1247 (1992)

[3] P.F. Brownell, L.M. Bielig. *The role of sodiu m in the conversion of pyruvate to phosphoenolpyruvate in mesophyll chloroplasts of C4 plants.* Aust. J. Plant Physiol. 23, 171 (1996)

[4] B. Macler, E. Bamberg, E. Moffatt, et al.. *Effects of salinity and nitrogen on growth, productivity and food value of Amaranthus in controlled culture*. Proc. 4th Nat. Amaranth Symp, pp. 129-141 (1990).

[5] P. Chang, K.W. Kim, S. Yoshida, et al. *Uranium accumulation of crop plants enhanced by citric acid.* Environ. Geochem. Health. 27, 529 (2005).

[6] P. Sharma, V. Sardana, S.S. Banga. *Salt tolerance of Indian mustard (Brassica juncea) at germination and early seedling growth.* Environ. Exp. Biol. 11, 39 (2013).