Studies Concerning Disposal Radionuclides by Adsorption Rabbit Bone Meal

MARIUS PENTEA[1], IONUT SARAC[1], IONEL SAMFIRA[1], ADINA NEGREA[2,*], MIHAELA CIOPEC[2], MARILENA MOTOC[3], ANDREEA GABOR[2], PETRU NEGREA[2], RAMONA BUZATU[4]

[1] Banat University of Agricultural Sciences and Veterinary Medicine Regele Mihai I al Romaniei, 119 Calea Aradului, 300645, Timisoara, Romania

[2] University Politehnica Timisoara, Faculty of Industrial Chemistry and Environmental Engineering, 2 Victoriei Sq., 300006 Timisoara, Romania

[3] Victor Babes University of Medicine and Pharmacy Timisoara, 2 Eftimie Murgu Sq., 300041 Timisoara, Romania

[4] Victor Babes University of Medicine and Pharmacy, Department of Biochemistry, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

In the present study was conducted research carried on the possibilities for removing radionuclides from aqueous solutions by adsorption on rabbit bone meal bred in captivity. The material was characterized by analysis of the dispersion X-ray (EDX), using QUANTA EGF microscope 250, in order to establish the composition and morphological structure of the material. The material was used for the adsorption of radionuclides from aqueous solutions namely cesium, strontium, lanthanum, thallium, europium and neodymium as well as forming part actinide group. From the experimental data was observed the increase of the initial concentration in the solution of the radionuclide. Also the ion adsorption capacity is increasing and remains constant at a given initial of concentration in the different radionuclides studied. We can consider this concentration as the concentration of balance.

Keywords: radionuclides, environment, rabbit bone meal, adsorption

Radionuclide water contamination is a global environmental problem [1]. Some of radionuclides, which present toxicity and therefore require a special attention in order to eliminate them from aqueous solutions, are: cesium, lanthanum and thallium, europium and neodymium. It is known that, from industrialization of meat resulting in parallel with the main products (tissue, fat) abattoir by-products classified as food and technical / nonfood; classification is relative [2], because some become raw material for non-food by-products for human consumption [3]. Of slaughterhouse waste (bones) resulting the slaughter domestic rabbits [4], it delivers the specialized enterprises dealing with machining and recovery [5].

From bones calcined resulting the bone meal and raw bones (finely crushed) to afford an animal feed quality to stimulate laying hens [6].

The rest of the internal organs and other wastes are dehydrated and processed in special in flour fodder for animals [7]. Adsorption is the phenomenon whereby a solid or liquid - adsorbent - retain on its surface solid, liquid or gaseous - adsorbent - in the surrounding fluid medium. In the chemical industry and other fields, adsorption is used as operation of separation, purification and recovery; effective adsorbents retain one or more components of a mixture homogeneous or heterogeneous. Desorption, adsorption substances are set free [8]. After desorption, the adsorbent could be used again for adsorption. When the adsorbed substances cannot be removed by desorption, the adsorbent is reactivated by calcination or other operations [9]. Numerous technical applications of adsorption resulting from the three characteristics, in order to distinguish the adsorption of other separation processes: precipitation, coagulation, sedimentation, filtration, pressing, sublimation, crystallization, evaporation, distillation, rectification, extraction, adsorption [10].

These three characteristics of the adsorption are: retaining small particles, retention of components which are the minimum concentrations of physical adsorption [11]; chemical adsorption, resulting from the forces and chemical bonds between the adsorbent and the adsorbed substance [12]; and per adsorption, particular case of chemical adsorption, the retention of certain substances whose molecules adapts structural gaps crystallographic network of adsorbent, with the role of a molecular sieve [13].

The technological scheme of the process of metal pollutant removal by adsorption is shown in figure 1.

The wastewater containing from Strontium may be treated with adsorbent materials (ie. silica / florisil

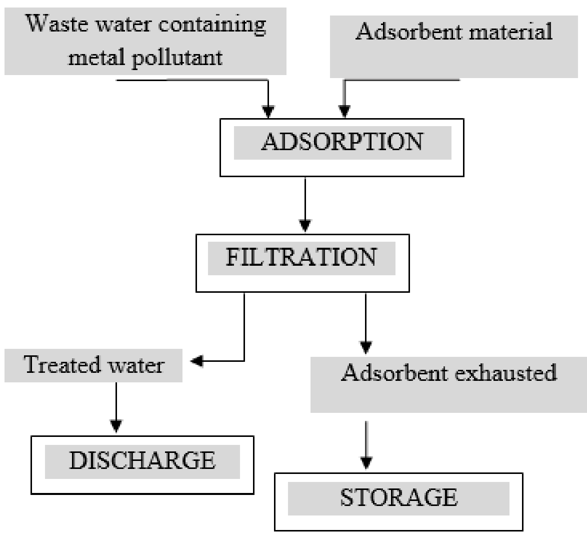


Fig. 1. The technological scheme of removal process to metal pollutant via adsorption

* email: adina.negrea@upt.ro; Tel.: +40 256 404192

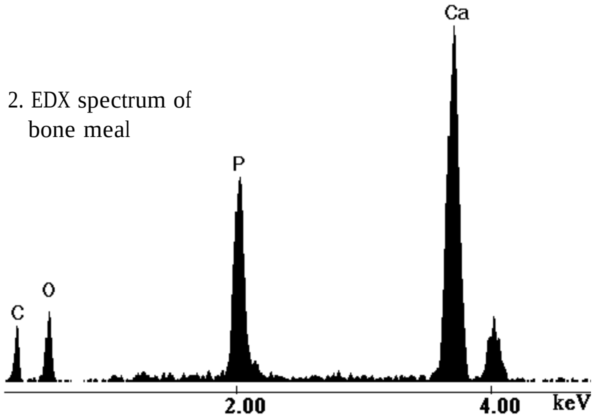


Fig. 2. EDX spectrum of bone meal

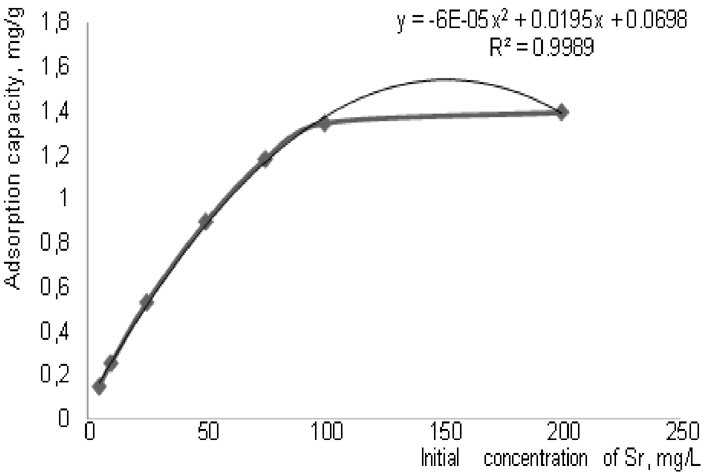


Fig. 4. The influence of the initial concentration of adsorption capacity of Sr (II)

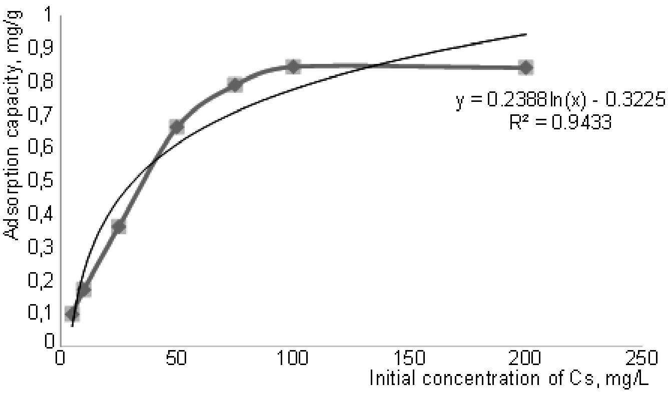


Fig. 3. The influence of the initial concentration of adsorption capacity of Cs (I)

impregnated with the ionic liquid) to retain the metal from to them.

After separation through filtration resulting treated water that can be discharged and exhausted adsorbent is sent to hazardous waste landfills.

In the present research were performed studies on the possibilities for removing radionuclides from aqueous solutions by adsorption on rabbit bone meal, processed beforehand.

Experimental part

Materials and methods

Bone samples were collected from rabbits bred in captivity. Rabbit bones were moistened in a solution of sodium hydroxide (0.8%), bone ratio: NaOH was 1: 2 to 90°C for 1 h. Then, bone residues were rinsed with deionized water (distilled) and dried in an oven at 100°C (≈12 h). Reducing the size of the bone dry samples was performed using a homogenizer at 15,000 rpm for 4 min. The bone powder was maintained under vacuum to -20°C characterizations. The material thus obtained dispersion was characterized by X-ray analysis (EDX), using QUANTA EGF microscope 250, in order to establish the composition and morphological structure of the material. The material used for the adsorption of radionuclides in aqueous solutions, namely: cesium, strontium, which is part of the main, groups I and II of periodic table lanthanum and thallium, which are part of the group of lanthanides europium and neodymium as well as that part of the actinide group. To study the properties of the adsorbent material (bone meal of rabbit bred in captivity). The influence of the initial concentration was monitored radionuclide: Cs(I), Sr(II), La(III), Tl(I), Eu(II) and Nd(III), of its maximum capacity for adsorption. To establish the influence of the initial concentration of the process of adsorption of radionuclides from aqueous solutions, and solutions were used radionuclides different concentrations, namely: Cs(I) and Sr(II): 5, 10, 25, 50, 75, 100, and 200 mg/L; Tl(I): 5, 10, 25, 50, 75, 100, 200, 300 and 400 mg/L; and La(III), Eu(II) and Nd(III): 5, 10, 25, 50, 75, 100, 200, 300, 400 and 500 mg/L.

The samples were stirred for 2 h, and then filtered, and the resultant solution was determined by the residual concentration of ions of radionuclides (the six enumerated more above), through Inductively *Coupled Plasma Mass* Spectrometry or *ICP-MS* using a plasma emission spectrophotometer coupled with mass detector, BRUKER Aurora M 90 [14].

Results and discussions

Material characterization (rabbit bone meal bred in captivity)

Materials used have been determined through the composition and morphological structure and physico-chemical methods namely Dispersive X-ray analysis (EDX), (fig. 2).

EDX spectrum is observed that the mineral phase consists of calcium and phosphorus may be best characterized as a poorly crystalline hydroxyapatite, the empirical formula is $(PO_4)_6(OH)$. Observe and other ions (A and C), specific organic phase.

The influence of the initial concentration of radionuclides

Experimental data about the influence of the initial concentration of the ions from the radionuclides on the adsorption process of the studied material (bone-meal rabbit) [15], with stirring for 2 h and at 298 K are shown in figures 3 - 9.

From the experimental data, for the influence of the initial concentration ~~of~~ in the adsorption capacity of Cs (I) was observed the increase of the initial concentration of cesium ions in the solution. The adsorption capacity [16], remains constant at an initial concentration of 100 mg / L.

We can consider this concentration as a steady concentration [17]; maximum adsorption capacity is 0.845 mg / g material. Determined an logarithmic model *equation* to represent this data that adsorption capacity of Cs(I) is $y = 0.2388\ln(x) - 0.3225$, and correlation coefficient $R^2 = 0.9433$.

From the experimental data can be observed when increase the initial concentration of strontium ions in the solution the adsorption capacity also increasing [18]. The adsorption capacity remains constant at an initial concentration of 100 mg / L. Thereby we can consider the this concentration as steady concentration, maximum

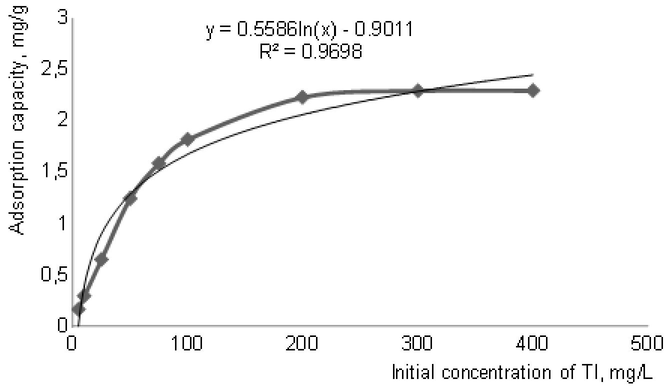


Fig. 5. The influence of the initial concentration of adsorption capacity of Tl (I)

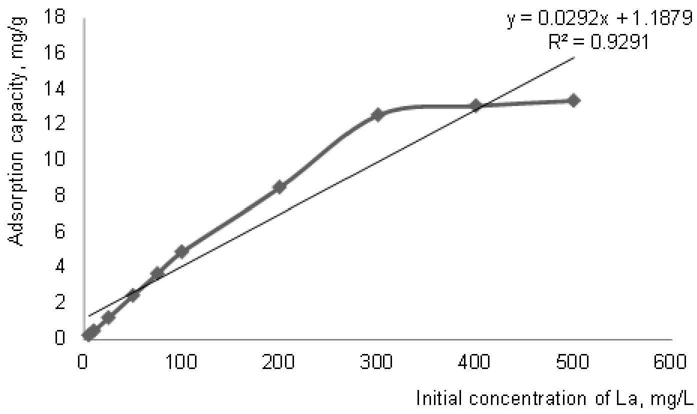


Fig. 6. The influence of the initial concentration of adsorption capacity of La (III)

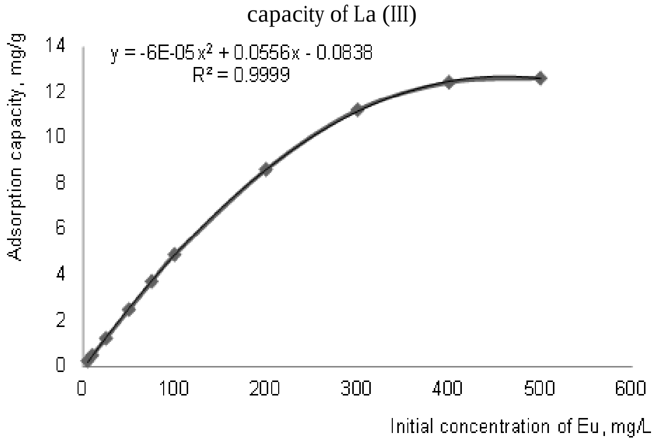


Fig. 7. The influence of the initial concentration of adsorption capacity of Eu (II)

adsorption capacity is 1.344 mg / g material. Polynomial equation adsorption capacity of Sr (II) is $y = -6E\text{-}05x^2 + 0.0195x + 0.0698$ and correlation coefficient $R^2 = 0.9989$.

From the experimental data, when the initial concentration of thallium ions in the solution increasing, the adsorption capacity [19], remains constant at an initial concentration of 200 mg / L. So can we consider this concentration as steady concentration; maximum adsorption capacity is 2.226 mg / g material. Logarithmic equation of the adsorption capacity of Tl (I) $y = 0.5586\ln(x) – 0.9011$ and correlation coefficient $R^2 = 0.9698$.

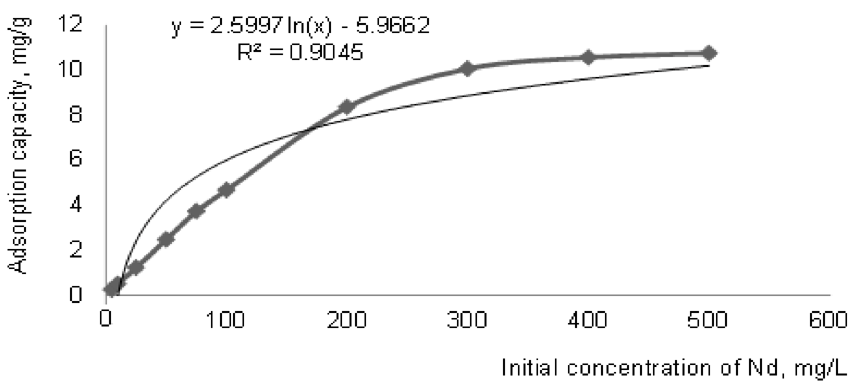
From the experimental data when the initial concentration of lanthanum ions in the solution ~~is~~ increasing, the adsorption capacity [20], remains constant at an initial concentration of 300 mg / L. Can we consider this concentration as steady concentration; maximum adsorption capacity is 12.569 mg / g material. Linear equation adsorption capacity of La (III) $y = 0.0292x + 1.1879$ and correlation coefficient $R^2 = 0.9291$.

From the experimental data when the initial concentration of the europium ions from the solution increasing the adsorption capacity [21], remains constant at an initial concentration of 400 mg / L. We can consider this concentration as steady concentration; maximum adsorption capacity is 12.452 mg / g material. Adsorption capacity of Eu (II) is described by the following polynomial equations $y = -6E\text{-}05x^2 + 0.0556x - 0.0838$ and correlation coefficient $R^2 = 0.9999$.

From the experimental data when the higher the initial concentration of neodymium ions of the solution ~~is~~ increasing the adsorption capacity [22], remains constant at an initial concentration of 400 mg / L. We believe this concentration as steady concentration, maximum adsorption capacity is 10.561 mg / g material. The *logarithm equation of* adsorption capacity of Nd (III) $y = 2.5997\ln(x) - 5.9662$ and $R^2 = 0.9045$. From the experimental data it is observed that with the increase of the initial concentration of the solution of the radionuclide ion adsorption capacity is increasing and remains constant at a given initial concentration [23], the different radionuclides studied [24]. We believe this concentration as the concentration of balance.

From figure 9 it is noted that: Cs(I) adsorption capacity limit is 100 mg / g material; Maximum capacity of adsorption for Sr(II) is 100 mg / g material; Tl(I) adsorption capacity limit is 200 mg / g material; Maximum capacity of adsorption for La(III) is 300 mg / g material; Eu(II) adsorption capacity limit is 400 mg / g material; Nd(III) adsorption capacity limit is 400 mg / g material. It also notes that the studied material (rabbit bone meal) has high affinity for Eu(II) and Nd(III)(Ce = 400 mg / g material). From experimental data is observed that the largest adsorption capacity lanthanum and europium La(III) and Eu(II) presents the material studied.

Fig.8. The influence of the initial concentration of adsorption capacity of Nd (III)



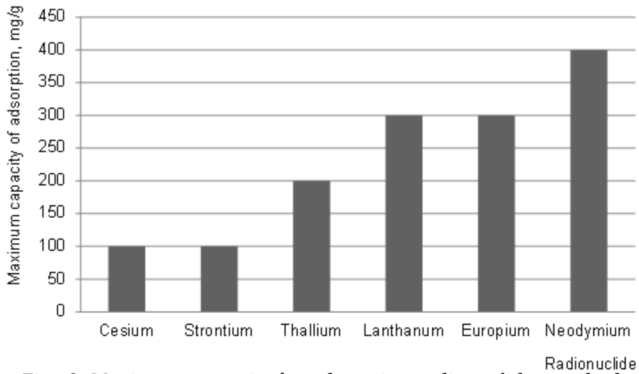


Fig.. 9. Maximum capacity for adsorption radionuclides studied

Conclusions

Based on studies on the influence of the initial concentration of radionuclides on maximum adsorption capacity of rabbit bone meal showed the following: Cs(I) equilibrium concentration is 100 mg / L; the maximum adsorption capacity is 0.845 mg / g material; Equilibrium concentration of Sr(II) is 100 mg / L; the maximum adsorption capacity is 1.344 mg / g material; Tl(I) steady concentration is 200 mg / L; the maximum adsorption capacity is 2.226 mg / g material; La(III) steady concentration is 300 mg / L; the maximum adsorption capacity is 12.569 mg / g material; Eu(II) steady concentration is 400 mg / L; the maximum adsorption capacity is 12.452 mg / g material; Nd(III) steady concentration is 400 mg / L; the maximum adsorption capacity is 10.561 mg / g material. In conclusion, based on the study's results, we can say that rabbit regrown bone meal in captivity shows a high adsorption capacity generally being a cheap material and does not require functionalization. At the same time can be used successfully in the adsorption of radionuclides are rare and expensive elements, which is very important recovery of aqueous solutions.

References

1.BAGIU, R. V., VLAICU, B., BUTNARIU, M., Int. J. Mol. Sci., **13**, no. 2, 2012, p. 1426.
2.IANCULOV, I., PALICICA, R., BUTNARIU, M., DUMBRAVA, D., GERGEN, I., Rev. Chim.(Bucharest) **56**, no. 4, 2005, p. 441.
3.BUTNARIU, M., Chem. Cent. J., **6**, 2012, p. 75.
4.BUTU, M., RODINO, S., BUTU, A., BUTNARIU, M., Dig. J. Nanomater. Bios., **9**, no. 2, 2014. p. 519.
5.BOSTAN, C., BUTNARIU, M., BUTU, M., ORTAN, A., BUTU, A., RODINO, S., PARVU, C., Rom. Biotech. Lett., **18**, no. 2, 2013, p. 8190.
6.BUTNARIU, M., CAUNII, A., Ann. Agric. Environ. Med., **20**, no. 4, 2013, p. 736.
7.FERENCZ, A., JUHASZ, R., BUTNARIU, M., DEER, A.K., VARGA, I.S., NEMCSOK, J., Acta Biol. Hung., **63**, no. 1, 2012, p. 15.
8.CAUNII, A., BUTU, M., RODINO, S., MOTOC, M., NEGREA, A., SAMFIRA, I., BUTNARIU, M., Rev. Chim.(Bucharest), **66**, no. 4, 2015, p. 472.
9.BUTNARIU, M., BOSTAN, C., African journal of biotechnology, **10**, no. 31, 2011, p. 5900.
10.IANCULOV, I., GERGEN, I., PALICICA, R., BUTNARIU, M., DUMBRAVA, D., GABOR, L., Rev. Chim.(Bucharest), **5**, no. 11, 2004, p. 835.
11.BUTNARIU, M., RODINO, S., PETRACHE, P., NEGOESCU, C., BUTU, M. Dig. J. Nanomater. Bios., **9**, no. 2, 2014, p. 745.
12.BARBAT, C., RODINO, S., PETRACHE, P., BUTU, M., BUTNARIU, M., Dig J Nanomater Bios, **8**, no. 3, 2013, p. 945.
13.BUTNARIU, M., CAUNII, A., PUTNOKY, S., Chem. Cent. J. **6**, 2012, 146.
14.RASHED, K., BUTNARIU, M., Iran J. Pharm. Res., **13**, no. 3, 2014, p. 1073.
15.BUTNARIU, M., SMULEAC, A., DEHELEAN, C., CHIRITA, R., SARATEAN, V., Rev. Chim.(Bucharest), **57**, no. 11, 2006, p. 1138.
16.CAUNII, A., NEGREA, A., PENTEA, M., SAMFIRA, I., MOTOC, M., BUTNARIU, M., Rev. Chim. (Bucharest), **66**, no. 3, 2015, p. 382.
17.BUTNARIU, M., GOIAN, M., IANCULOV, I., GERGEN, I., NEGREA, P., Rev. Chim.(Bucharest), **56**, no. 8, 2005, p. 837.
18.BUTU, M., RODINO, S., PENTEA, M., NEGREA, A., PETRACHE, P., BUTNARIU, M., Dig. J. Nanomater. Bios., **9**, no. 4, 2014, p. 1317.
19.PUTNOKY, S., CAUNII, A., BUTNARIU, M., Chem. Cent. J., **7,** 2013, 146.
20.BUTU, M., BUTNARIU, M., RODINO, S., BUTU, A., Dig. J. Nanomater. Bios, **9**, no. 3, 2014, p. 935.
21.RODINO, S., BUTU, M., NEGOESCU, C., CAUNII, A., CRISTINA, R. T., BUTNARIU, M., Dig. J. Nanomater. Bios., **9**, no. 3, 2014, p. 1215.
22.PENTEA, M., BUTU, M., SAMFIRA, I., CRISTINA, R. T., BUTNARIU, M., Dig. J. Nanomater. Bios., **10**, no. 1, 2015. p. 291.
23.BUTU, M., RODINO, S., BUTU, A., BUTNARIU, M., Dig. J. Nanomater. Bios., **9**, no. 2, 2014, p. 519.
24.CIOPEC, M., NEGREA, A., PENTEA, M., SAMFIRA, I., MOTOC, M., BUTNARIU, M., Rev. Chim.(Bucharest), **66**, no. 5, 2015, p. 645.

Manuscript received: 12.09.2015