Aspects Concerning the Selection of Ion Exchange Resin for Low Level Radwaste Waters Decontamination

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This paper presents an experimental investigation characterizing the use of fixed bed ion exchange for simultaneous removal of ^{60}Co and ^{137}Cs radionuclides and of anionic surfactant sodium linear alkyl benzene sulphonate from waste waters resulted in processing of spent nuclear fuel. The first experimental studies were carried out with simulated, non-radioactive, water systems. The use of water radioactive waste as the case of spent decontamination solutions was also checked in experimental investigation. The treatment of radioactive solutions by ion exchange technique was carried at two flow rates and at 25^{0}C. Experimental results obtained in simulated non radioactive system using ion exchange resins Purolite NRW 5050 or mixture with Purolite NRW 160 and Purolite NRW 3550 have shown their effectiveness in decontamination of polluted water with cobalt ions and anionic surfactant. In the tests with radioactive system the ion exchanger Purolite 1600 can be effectively used to achieve a high decontamination of polluted water containing fission products (^{60}Co, ^{137}Cs) from the spent decontamination solutions.

Keywords: radioactive waste water, ion exchange resins, decontamination, breakthrough curve

The waste waters from Cernavoda NPP, containing corrosion products and fission products, fall in the category of low level radioactive waste. These waste waters must be treated in order to be decontaminated prior to be released in Danube River. Additionally these wastewaters contain some organic products, like surfactants from laundry (mainly sodium linear alkyl benzene sulfonate-LABSNa). The ion exchange is the most efficient treatment technology for radionuclides removal from a variety of water waste streams with low and intermediate pollution level.

With respect to the economical aspects and process efficiency the ion exchange stands between evaporation and chemical precipitation as liquid waste treatments processes. While evaporation process may yield higher decontamination factors, it is also more expensive than ion exchange process. The development of new ion exchangers is narrowing the gap on decontamination factors values between evaporation and ion exchange processes. Chemical precipitation, however, is often less expensive but is not always effective in removing radionuclides from solution [1-4].

In the most cases it is used the ion exchange in fixed bed procedure. It is a dynamic procedure with the best characterization by means of a breakthrough curve. The breakthrough curve shows the solute or ion concentration in the effluent on the y-axis versus the effluent throughput volume or time on the x-axis. The area above the breakthrough curve represents the amount of solute or ions taken up by the column. This area is given by the below relation, where C_0 is contaminant concentration in affluent, C_e is contaminant concentration in effluent, V is the effluent volume, variable from $V = 0$ to V as the allowable throughput volume under consideration.

$$A = \int_0^V (C_0 - C_e)dV \qquad (1)$$

The area above the breakthrough curve is equal to the amount of ions removed by the column. At curve is equal to the maximum amount of ions removed by the column. In the case of complete saturation of the bed with retained ions the entire exchange column is in equilibrium with the influent and effluent flows. The breakthrough point is the point where the effluent concentration suddenly increases. The saturation point is the point where the effluent concentration is practically equal with the affluent concentration (C_e/C_0 =0.95-0.99) [5-10].

Ion exchange particle diameter, temperature, liquid flow rate in the bed, nature of the functional group on the ions exchanger, cross-linking degree of the polymers from ion exchanger, ions concentration in the processed solution and valence of the retained species are the most known parameters that affect the time positioning of a breakthrough curve [11-14]. It is important to shows that the laboratory obtained breakthrough curve in ion exchange can be easy used to scale up of fixed bed investigated process. If it is obtained the dependence of breakthrough point on process parameters then it can be used as first base in process scale –up [11,15]

Experimental part

Materials and methods

The experimental investigation of surfactant (LABSNa) and radionuclides ^{60}Co, ^{137}Cs removal, from radioactive waste waters in the fixed bed ion exchange procedure, express the paper aim. The elevation of the characteristic breakthrough curves gives consistency of the paper aim. Since the radwaste waters may contain a mixture of surfactants and cations, for decontamination are required anionic and cationic resins. The experiments were performed using simulated two components non-radioactive system (LABSNa and a cation) and then by mean of real in radioactive system.

In the experiments were tested strong R-H and R-OH ion exchangers. The bellow presented data give some

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Table 1
THE ION EXCHANGE RESINS USED IN THE EXPERIMENTS

RESIN	IONIC FORM	TOTAL CAPACITY, eq/l	MOISTURE RETENTION, %	PARTICLE SIZE RANGE, µm	APPLICATIONS
NRW 160	H+; Strong acid cation	2.1	43-48	420-1200	**Cationic exchange resin for nuclear use.** Selective for ^{137}Cs.
NRW 1600	H+; Strong acid cation	2.1	43-48	570±50	**Cationic exchange resin for nuclear use.** Cation resin vessels or layering for added cation capacity.
NRW 5050	OH^- Macroporous Strong Base Anion	0.9	53-58	570±50	**Anionic exchange resin for nuclear use.** Porous structure designed to give greater resistance to surface fouling in a wide range of nuclear applications.
NRW 3550	H^+/ OH	H^+: 2.1 OH^-: 0.9 Eq. ratio: 1:1	-	425-1200	**Mixed bed products for nuclear use.** For high organics water and boron removal.

characteristics of ion exchange resins from Purolite which was used in our experimental investigations.

The chemicals used for preparation of simulated polluted water systems were cobalt chloride and LABSNa. Some facts about these chemicals are given in the following.

Cobalt chloride $CoCl_2$ - Merck Millipore

Molecular weight: 129.83 g/mol; Solubility in water (20 °C): soluble; Melting point: 735 °C; Density: 3.36 g/cm3 (25 °C); Boiling point: 1049 °C (1013 hPa).

LABSNa -linear alkyl benzene sulfonic acid sodium salt

Molecular weight: 348.48 g/mol; Solubility in water: soluble; Melting point: -5 °C; Density: 1060 g/cm^3 (20 °C).

The characteristics of the waste radioactive waters were: *p*H=7.47; conductivity = 0.362 mS/cm; TDS (total dissolved solids) = 0.175 g/L; radioactive contaminants are ^{110}Ag, ^{60}Co , ^{125}Sb, ^{134} Co, ^{137}Cs, ^{95} Zr, ^{95}Nb and ^{3} H. Radioactive concentrations of the mainly nuclides - cobalt and strontium are 389±6 Bq/L ^{60}Co and 19221 ± 237 Bq/L ^{137}Cs. This waste waters did not contain anionic surfactants. Other non radioactive cations identified by emission spectrometry with inductively coupled plasma (ICP-OES, ICAP model 6500) are: Al 1.93 ppm, B 0.12 ppm, Ba 0.04 ppm, Ca 12.20 ppm, Cr 0.06 ppm, Ga 0.01 ppm, K 3.41 ppm, Mg 4.59 ppm, Na 18.30 ppm.

Analytical methods in simulated systems

Determination of Anionic Surfactants (LABSNa) through two-phase titration

The analytical method is based on titration of anionic surfactant with a cationic surfactant (hyamine 1622 - benzethonium chloride) in the presence of an indicator from a mixture of cationic dye (diimidium bromide) and an anionic dye (disulphine Blue). Titration takes place in two phases, the aqueous phase and chloroform phase, at the end point the organic phase turning from pink to blue-gray. When it is used as a titrant a 0.004 M solution, the concentration of LABSNa in mg/L is given by relation (2):

$$C_{LABSNa} = V \times f \times d \times 348 \times 0.004 \qquad (2)$$

Here *V* is the volume of 0.004 M Hyamine solution used at titration, *f* is the correction index for 0.004 M Hyamine solution, *d* is the dilution ratio and 348 is molecular weight of LABSNa.

Determination of cobalt content

The method is based on Co complexation with ethylene diamine tetra acid disodium salt (Complexon III) in the presence of murexid as indicator. The content of Co^{2+}, expressed in mg/l, is calculated according to relation (3) where V is the volume of 0.01 M of Complexon III used for titration, *f* is the correction index for solution 0.01 M of Complexon III and *d* is the dilution ratio. The constant 0.5893 shows the amount of Co^{2+} reacted with a 1 mL of 0.01 M of Complexon III.

$$C_{Co^{2+}} = V \times f \times d \times 0.5893 \qquad (3)$$

Measurement apparatus and instruments for experiments with radioactive waste waters

Characterization of the solutions as concerns the radioactive composition was performed by measurement concentrations of gamma emitting radionuclides with a high resolution spectrometer composed of a HPGe detector with 25% relative efficiency, a low background shielding and a Canberra spectrometric analyzer. The analysis software was GENIE-2000 from Canberra. The spectrometer was energy and efficiency calibrated in the range 60 keV – 1500 keV, by considering all counting geometries used in the experiments. The nuclear properties values used for data reduction were gathered from the original generic library of the software GENIE 2000 v. 1.2.

Experiments in simulated non radioactive system were conducted in an installation consisting of: I) glass column, containing ion exchange resin, with inner diameter of 1.8 cm and height of 20 cm; height of the ion exchange resin in the column was varied between 4.5 and 10 cm; the waste water flow rate through the ion exchange resin was varied between 0.83 cm^3/min (50 cm^3/h) and 6.67 cm^3/min (400 cm^3/h); II) dropping funnel with a volume of 500 mL, for feeding the solution containing cobalt ions and/or LABSNa in the glass column containing ion exchange resin ; III) a collection vessel for effluent. All experiments were done at 20^{0}C with descendent flow of the waste water in column. The experiments with radioactive waste water were performed in following conditions: dynamic column experiment; batch operation; descendent flow; fixed bed; ambient temperature 20±2 °C.

Results and discussions

Experimental tests in simulated non radioactive systems

The experiments with non-radioactive species in simulated polluted water were conducted in two stages: i) water with single-component as $CoCl_2$ solutions for Co^{2+} retention, respectively LABSNa surfactant solution for linear alkyl benzene sulfonic anion retention; ii) waters with two components as a mixture of $CoCl_2$ solution and LABSNa solution. In tables 2-4 are presented for each tested resin and solutions of contaminants the breaking point (time of breaking occurrence), the volume of processed solution (BV) until breaking point appears, the water flow rate in fixed bed in BV/h and respectively the volume of the solution passed on the resin until saturation. As it results from tables 2 and 3 the first series of breaking curves was

No. crt.	Resin	LABSNa initial concentration (mg /l) and temperature (^{0}C)	Breaking point		BV/h	Ratio of solution passed at saturation volume and resin volume
			Minutes	Bed volumes		
1	Purolite NRW 5050 Anionic resin	1000; 20	200	62.89	13.03	298.74
2	Purolite NRW 5050 Anionic resin	494.16; 20	2475	157.23	4.44	817.61
3	Purolite NRW 3550 Mixed resin	490; 20	1790	172.96	5.86	534.59

Table 2
BREAKING POINT OF ANIONIC RESINS IN A SIMULATED LABSNa SYSTEM

No. crt.	Resin	Cobalt initial concentration (mg /l) and and temperature (^{0}C)	Breaking point		BV/h	Ratio of solution passed at saturation volume and resin volume
			Minutes	Bed volumes		
1	Purolite NRW 160 Cationic resin	979.85	180	47.15	14.29	86.44
2	Purolite NRW 160 Cationic resin	447.36	940	62.89	4.66	330.19
3	Purolite NRW 1600 Cationic resin	447,82	720	47.16	4.88	298.74
4	Purolite NRW 3550 Mixed resin	447.36	150	17.46	5.86	104.8
5	Purolite NRW 3550 Mixed resin	241.61	735	47.16	5.50	141.51

Table 3
BREAKING POINT OF CATIONIC RESINS IN A SIMULATED COBALT DICHLORIDE SYSTEM

carried out with water having a single pollutant component namely LABSNa and respectively cobalt dichloride under constant temperature (20^{0}C) and by varying the solution flow rate (BEV/h) and solution concentration in the transferring species. In these tables was done data respect to the first point of the breakthrough curve characterizing the mentioned experimental investigations. These data was obtained from the corresponding breakthrough curve. The positioning of the first breakthrough point from a breakthrough curve depends on operating parameters of fixed bed pollutants separation by ion exchange. For water depollution it is recommended to stop the process when this point is attained.

From tables 2 and 3 and from theirs corresponding figures (figs 1-5) it observes that the positioning of this first breaking point is great when the polluted water flow rate and the pollutant concentration in water are low. In the case of LABS$^-$ removal in single-component system, both Purolite NRW 5050 resin (breaking point at 157.23 BV) and Purolite NRW 3550 resin (breaking point at 172.96 BV) are efficient for LABS$^-$ removal (table 2). The dynamic of decontamination process is evaluated according the two breaking curves, which show the evolution of the C_{ex}/C_0 ratio versus time for both resins (fig 1-2) above mentioned

Figure 1 show that for the Purolite NRW 5050 ion exchange resin the breaking point appears at 2475 min for the LABS$^-$ retention (input concentration is 494.16 mg/L) and saturation point is reached after 11040 min. At higher concentration of LABS$^-$ (1000 mg/L), the Purolite NRW 5050 resin shows worse results – breaking point at 200 min (table 2). In the case of Purolite NRW 3550 resin, at the concentration of LABS$^-$ of 490 mg/L, the breaking point appears at 1790 min and the saturation point at 5470 min (fig. 2).

In case of LABS$^-$ retention is to be mentioned a slower variation of concentration between the breaking point and saturation point. Thus, on the resin Purolite NRW 5050 breaking point occurs at 22% of the total time interval required to achieve saturation. For the same LABS concentration (494.16 mg/ L), Purolite NRW 3550 resin breakthrough point occurs at 32%.

In the case of Co^{2+} removal, in single component system, the Purolite NRW 160 resin is more efficient, followed by Purolite NRW 1600 and Purolite NRW 3550 (table 3). The breaking points appear at 62.89 BV (Purolite NRW 160), followed at 47.16 BV (for Purolite NRW 1600 and Purolite 3550).The dynamic process of Co^{2+} retention

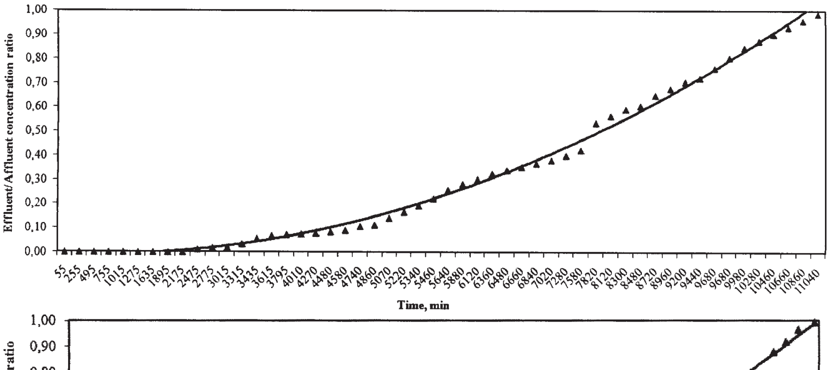

Fig. 1. The breaking curve of NRW 5050 resin for LABSNa versus time ($c_{0\ LABSNa}$ = 494.16 mg/L, resin volume =12.72 cm^3, temperature 20^{0}C, Flow rate 4.44 BV/h)

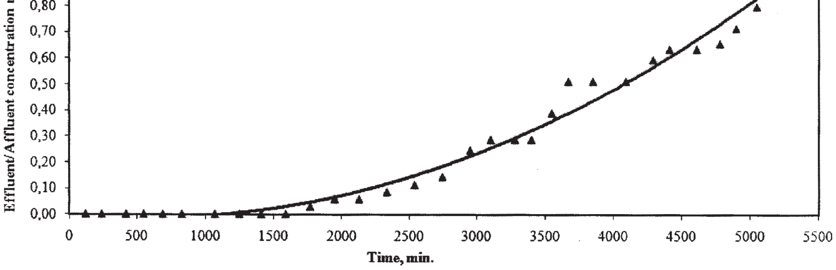

Fig. 2. The breaking curve of NRW 3550 resin for LABSNa versus time ($C_{0\ LABSNa}$ = 490mg/L, resin volume =12.72 cm^3, temperature 20^{0}C, Flow rate 5.86 BV/h)

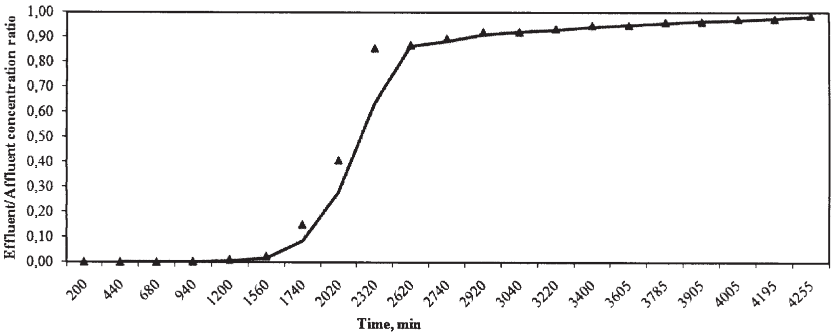

Fig. 3. The breaking curve of NRW 160 resin for Co^{2+} versus time ($C_{0\ Co2+}$ = 447.36 mg/L, resin volume =12.72 cm^3, temperature 20^{0}C, Flow rate 4.66 BV/h)

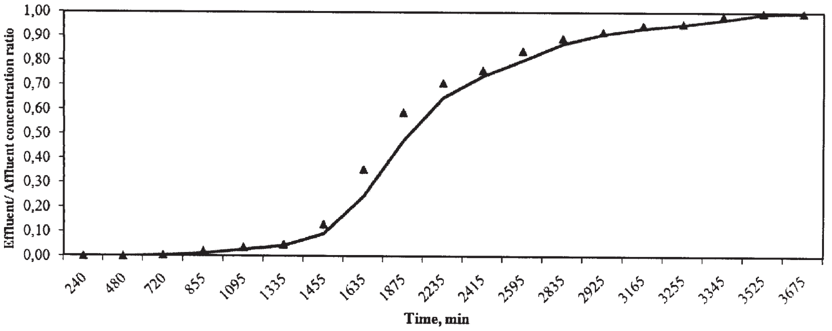

Fig. 4. The breaking curve of NRW 1600 resin for Co^{2+} versus time ($C_{0\ Co2+}$ = 447.82 mg/L, resin volume =12.72 cm^3, temperature 20^{0}C, Flow rate 4.88 BV/h)

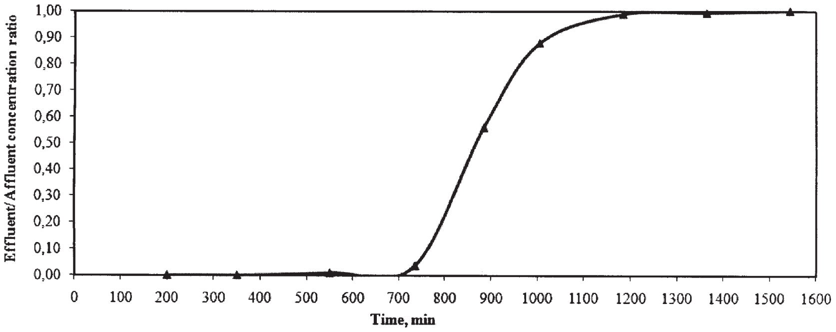

Fig.5. The breaking curve of NRW 3550 resin for Co^{2+} versus time ($C_{0\ Co2+}$ = 241.61 mg/L, resin volume =12.72 cm^3, temperature 20^{0}C, Flow rate 5.86 BV/h)

on Purolite NRW 160, Purolite 1600 and Purolite NRW 3550 is presented in figures 3-5.

The results presented in figure 3 show that the Purolite NRW 160 ion exchange resin has a breaking point for the Co^{2+} ion retention at 940 min (input concentration is 447.36 mg/L) and saturation point after 4255 min. The breaking point decreases at an increasing of concentration; a solution with 979.85 mg/L Co^{2+} ion passed on Purolite NRW 160 resin presents a breaking point at 180 min and a saturation point at 363 min (table 3). In the case of Purolite NRW 1600 (fig. 4) breaking point appears at 720 min and saturation point at 3675 min for an affluent concentration of 447.82 mg/L, similar results being obtained in the case of Purolite NRW 3550. The results presented in figure 5 showed that the Purolite NRW 3550 ion exchange resin has a similar capacity in Co^{2+} retention with Purolite NRW 1600, having a breaking point at 735 min and saturation point after 1075 min, for an input concentration of 241.61 mg/L.

After testing the mono component system, the following resins were selected: i) Purolite NRW 5050 with the best performance of LABS$^-$-anion retention; ii) mixed resin Purolite NRW 3550, both for anion-LABS$^-$ and Co^{2+} retention; iii) Purolite NRW 160 with the best performance for Co^{2+} retention.

The second series of tests were carried out with polluted water containing two components: LABSNa cobalt chloride through Purolite. As it is shows in table 4 the resins NRW 3550 as mixed resins and the coupled Purolite NRW 160 (first column) with Purolite NRW 5050 (the second column) has been selected for pollutants separation.

A comparison of results with polluted water with Co^{2+} and anion LABS$^-$ with those of mono component in water founds an improvement in retention of Co^{2+} and anion LABS$^-$; thus for Purolite NRW 3550 mixed resin the first breaking point occurs at 91.68 BV for Co^{2+} and at 288.14 BV for LABS$^-$whereas for the coupled Purolite NRW 160 and for Purolite 5050 the breaking point occurs at 78.61 BV for Co^{2+} and at 212.26 BV for LABS$^-$. The results presented in figure 6 show that the Purolite NRW 3550 resin has a breaking point for Co^{2+} ion retention after 865 minutes and for LABS ion retention after 3530 min. The saturation points for Co^{2+} and LABS$^-$ in these experiments appear at 7000 minutes after passing 10200 ml of the simulated solution.

The dynamics given by figure 6 and7 show the competition between the cations Co^{+2} and Na$^+$ and the anions LABS$^-$ and Cl$^-$ (sequential displacement of cations

No. crt.	Resin	LABSNa initial concentration (mg /l) and temperature (^{0}C)	Co initial concentration, mg/L	Breaking point,				BV/h	Ratio of solution passed at saturation volume and resin volume
				Minutes		Bed volumes			
				Co	LABSNa	Co	LABSNa		
1	Purolite NRW 3550 Mixed resin	434.16	247.83	865	3530	91.68	288.14	5.73	667.98
2	Purolite NRW 160 + Purolite 5050	250	223.68	1100	1270	78.61	212.26	5.33	1155.66

Table 4
BREAKING POINT OF MIXED RESINS IN A SIMULATED $CoCL_2$ + LABSNa SYSTEM

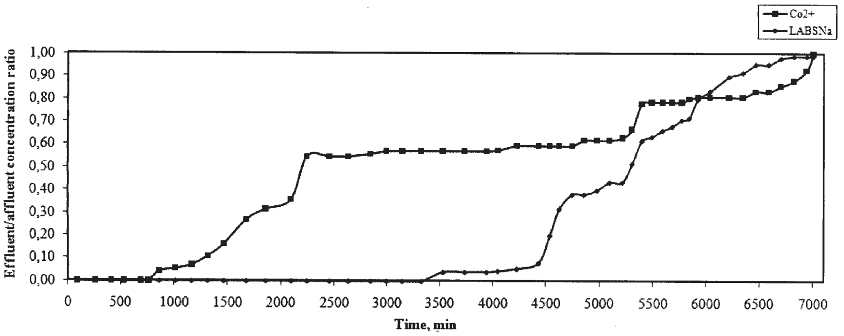

Fig. 6. The breaking curve of NRW3550 resin for Co^{2+} and LABSNa versus time ($C_{0\ Co2+}$ = 247.83 mg/L, $C_{0\ LABSNa}$ = 434.16 mg/L, resin volume =15.27 cm^3, temperature 20°C, Flow rate 5.73 BV/h)

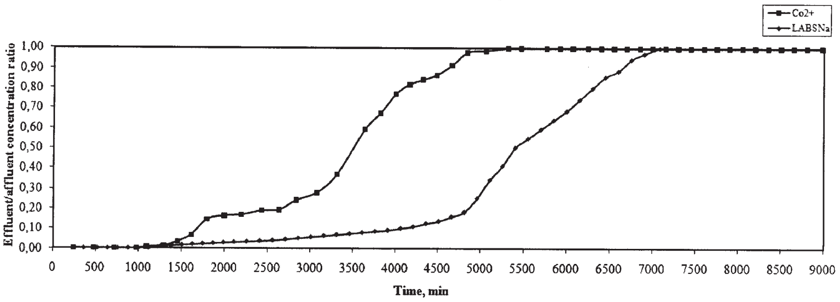

Fig. 7. The breaking curve of NRW160 and NRW 5050 resins for Co^{2+} and LABSNa versus time (C_0 Co^{2+} = 245.36 mg/L, C_0 LABSNa = 244.18 mg/L, resin volume =12.72 cm^3, temperature 20°C, Flow rate 5.33 BV/h)

Co^{+2} or Na^+, etc.) at their interaction with the resins of R-H and R-OH type. The Purolite NRW 3550 or coupled Purolite NRW 160 with Purolite NRW 5050 are resins of this type. This phenomenon is also encountered in radioactive system testing [16, 17]. Mixed resin Purolite NRW 3550 and the coupled Purolite NRW 160 with Purolite NRW 5050 show good efficiency for retention of the couple Co^{2+} and $LABS^-$ contaminants, significantly higher than in the case of single component system, as for Co^{2+} and $LABS^-$ retention. In the case of on the coupled Purolite NRW 160 and Purolite NRW 5050 the breaking point for Co^{2+} retention appears at 1100 min and for anion $LABS^-$ at 1270 min.

The time position of the both characteristic points of a breaking curves depends on resins characteristics (structure, type of ion exchange group, diffusion comportment of resin structure, etc.) and also on the external particle mass transfer of active species (liquid flow rate, liquid viscosity, liquid temperature, external diffusion coefficient, etc.). The above presented data accentuate on time position of the first characteristic point of the breaking curve. Unfortunately it is difficult to use above presented data for a scale up process. It is of more interest for process scale up the use of complete breaking curve in order to identify the ion exchange equilibrium. A breakthrough curve give phase's equilibrium composition based on the observation that in a saturated ion exchange bed the species composition of the exiting liquid is in equilibrium with composition of the resin retained species. The below relations can be used for obtaining of one point from an ion exchange isotherm when a single species ion exchange occurs in a fixed bed. Here τ_0 and τ_1 are the time values of first and respectively the second point of the breakthrough curve, G_v shows the value of the liquid flow rate in the bed and V_r is the resin volume from the analyzed experiments.

$$c_0 = c_e \tag{4}$$

$$Q_r = G_v(c_0\tau_0 + \int_{\tau_0}^{\tau_1} c(\tau)d\tau) \tag{5}$$

$$q_e = Q_r / V_r \tag{6}$$

The computation concerning ion exchange for above presented cases was concentrated in table 5. Looking at any of the pairs (c_e, q_e) it finds that all checked ion exchangers are particularly effective in separating of pollutants species from water (the high values of q_e show this). Data presented in this table are important for computation of these separations in batch contacting procedure; here the saturation ion exchanger is procedure goal.

Experimental tests in radioactive systems

Removal of ^{137}Cs and ^{60}Co from radioactive waste waters has been studied in order to obtain: i) the selection of the best active ion exchanger for treatment of this water; ii) the building of some breakthrough curves for treatment of this water when it changes the water flow rate in the bed; iii) the use of breakthrough curves for establishing of the state of water decontamination factor versus the volume of treated water. The particularity of the experimental tests is given by the fact that the used radioactive waste waters contain ^{60}Co with low concentration and ^{137}Cs with high concentration (table 6 respect to these species radioactivity in initial solutions). The checked radioactive waste waters were filtered in order to eliminate the radioactivity given by the suspended solids therein contained.

The preliminary tests with radioactive water show that the cationic Purolite NRW1600 ion exchanger, at 10 BV/h, respectively the mixed anionic and cationic resin Purolite 3550 ion exchanger, at 20 BV/h, give to interesting results. The breakthrough curves of ^{60}Co and of ^{137}Cs through the column of Purolite NRW 1600 cationic exchange resin are shown in figures 8 -9 and table 6.

In the case of retention of $^{60}Co^{2+}$ and Cs^+ on Purolite NRW 1600 resin (fig 8), the first point of the breakthrough curve appears at 5100 min; it is followed by an interesting comportment in ion exchange where $^{60}Co^{+2}$ starts to release $^{137}Cs^+$ from the solid and consequently $^{137}Cs^+$ appears in fixed bed effluent at concentrations higher than in affluent. If it takes into account that in radioactive water the Co^{+2} concentration is six or less that those from the simulated water then the results from figure 8 is compatible with those from figure 4. So is not a different response of Purrolite NRW 1600 resin to radioactive or non-radioactive Co. Referring to Cs retention figure 8 shows that the first breaking point appears at 4800 min; after this time begins their displacement (at 6500 min the ratio C_e/C_0 is over 2) from the ion exchanger. To this process ^{60}Co from solution or eluted from the basis of the fixed bed participates with

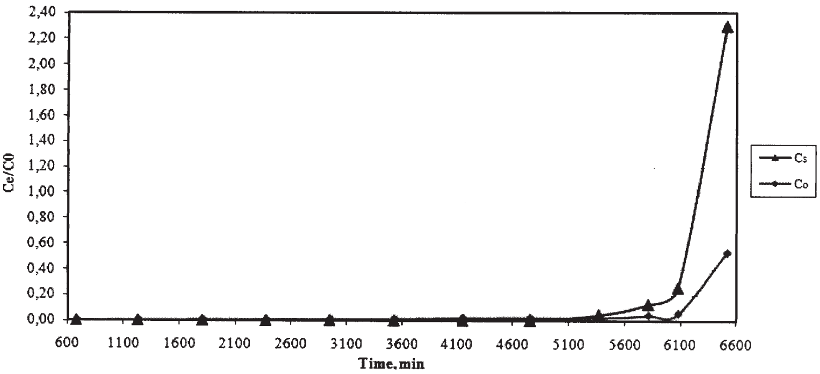

Fig. 8. Breaking curves of ^{60}Co and ^{137}Cs on Purolite NRW 1600 (flow rate 10BV/h, resin volume =12.72 cm^3, temperature 20^{0}C)

Table 5
BREAKTHROUGH CURVES IN RADIOACTIVE SYSTEMS AT 20^{0}C

No. crt.	Resin	^{60}Co initial activity, Bq/L	^{137}Cs initial activity, Bq/L	Breaking point				BV/h
				^{60}Co		^{137}Cs		
				Minutes	Bed volumes	Minutes	Bed volumes	
1	Purolite NRW 1600	389 ± 6	19221 ± 237	800	130	4800	740	10
2	Purolite NRW 3550	70 ± 4	19175 ± 243	200	22	400	45	20

Table 6
EQUILIBRIUM DATA FOR SOME INVESTIGATED RESIN-SIMULATED WATER SYSTEMS AT 20^{0}C

Nr crt	Resin systems and water flow rate	Simulated water case	Bed volume, cm^3	Breakthrough caracteristics				Equilibrium composition
				0.05 c_0	τ_0, min	0.95 c_0	τ_1, min	
1	Purolite NRW 5050 Anionic resin, 4.4 BEV/h	Water LABSNa solution , c_0= 494,16 mg/l	12.72	0.05 c_0	3170	0.95 c_0	10860	$c_e = 0.494\ g_{LABSNa}/l_{lq}$ $q_e = 256\ g_{LABSNa}/l_{rs}$
2	Purolite NRW 3550 Mixed resin, 5.6 BEV/h	Water LABSNa solution , c_0= 490,1 mg/l	12.72	0.05 c_0	5000	0.95 c_0	10800	$c_e = 0.49\ g_{LABSNa}/l_{lq}$ $q_e = 160.1\ g_{LABSNa}/l_{rs}$
3	Purolite NRW 160 Cationic resin, 4.66 BEV/h	Water Co^{+2} solution , c_0= 447,1 mg/l	12.72	0.05 c_0	1400	0.95 c_0	2450	$c_e = 0.447\ g_{Co+2}/l_{lq}$ $q_e = 66.85\ g_{Co+2}/l_{rs}$
4	Purolite NRW 3550 Mixed resin, 5.6 BEV/h	Water Co^{+2} solution , c_0= 241,36 mg/l	12.72	0.05 c_0	710	0.95 c_0	1125	$c_e = 0.241\ g_{Co+2}/l_{lq}$ $q_e = 20.30\ g_{Co+2}/l_{rs}$
5	Purolite NRW 3550 Mixed resin, 5.73 BEV/h	Water Co^{+2} and LABSNa solution , c_{01}= 241,36 mg/l, c_{02}= 431,3 mg/l,	15.75	0.05 c_0	680 3400	0.95 c_0	6800, 6800	$c_e = 0.241\ g_{Co+2}/l_{lq}$ $q_e = 86.207\ g_{Co+2}/l_{rs}$ $c_e = 0.431\ g_{LABSNa}/l_{lq}$ $q_e = 210,1\ g_{LABSNa}/l_{rs}$
6	Purolite NRW 160 Cationic resin, col1; Purolite NRW 5050 Anionic resin, col2, 5.33 BEV/h	Water Co^{+2} and LABSNa solution , c_{01}= 245,36 mg/l, c_{02}= 244,1 mg/l	12.72, 12.72	0.05 c_0	800, 3200	0.95 c_0	6800, 6800	$c_e = 0.245\ g_{Co+2}/l_{lq}$ $q_e = 57.76\ g_{Co+2}/l_{rs}$ $c_e = 0.244\ g_{LABSNa}/l_{lq}$ $q_e = 104.1\ g_{LABSNa}/l_{rs}$

strong intensity [16-17]. The breakthrough curves of ^{60}Co and of ^{137}Cs through the column of Purolite NRW 3350 are presented in figure 9.

It observes that the firs breakthrough point appears earlier on Purolite NRW 3550 than in the case of Purolite NRW 1600. The evolution after this time point shows constant ^{60}Co in effluent whereas ^{137}Cs go over the value of C_e/C_0 =1 and later comeback to Ce/C_0 =1. This behavior confirms the hypothesis of Cs displacement by other radioactive cations. From the point of view of technological applications, Purolite NRW 1600 resin, with an ability to decontaminate 750 BV of waste (flow of 10 BV / h), is considered efficient.

Decontamination factor (DF) is the ratio of the initial amount of a specified activity to the remaining amount of residual activity after the treatment. The DF may be expressed relative to gross activity or for a particular radionuclide. The decontamination factor for ^{60}Co and for ^{137}Cs was calculated and then plotted vs. the volume of treated solution, expressed in the units of bed volumes of the ion exchange resin (fig. 10). The obtained values of ^{60}Co and ^{137}Cc decontamination factor show the applicability of Purolite NRW-1600 ion exchange resin for the treatment of radioactive waste water, generated in processing of some radioactive materials.

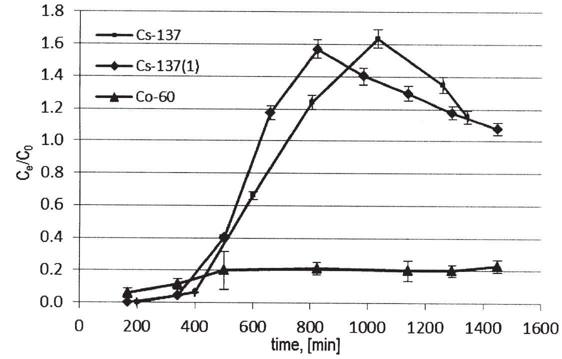

Fig. 9. Breakthrough curves of ^{137}Cs and ^{60}Co on Purolite NRW 3550 (flow rate 20BV/h, resin volume =12.72 cm^3, temperature 20^{0}C)

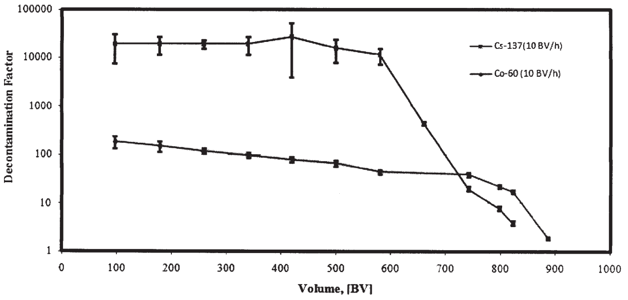

Fig. 10. Influence of flow rate on the decontamination factor for ^{60}Co and ^{137}Cs

Conclusions

The interest in the use of ion exchangers in processing of water polluted with radioactive species is great. In a given case the laboratory testing are essential for choosing the best ion exchanger. For the treatment of polluted water with LABS$^-$, Co^{+2} and Cs$^+$ ions were tried Purolite exchange resins type. Revealed the following: i) Purolite NRW 5050 anionic ion exchange resin give good results for processing of waters containing anionic surfactants (LABSNa); ii) waters containing Co^{+2}can be processed with the resins Purolite NRW 160 , Purolite NRW 1600 and Purolite NRW 3550; iii) two coupled fixed bed containing Purolite NRW 160 and respectively Purolite NRW 5050 or single fixed bed from mixed resins Purolite NRW 3550 give good results in processing of waters containing anionic surfactant and Co^{2+} ions; iv) the Purolite NRW 1600 resin provides the necessary decontamination factor for 850 BV radioactive waste treated at the 10 BV/h flow rate; v) the decontamination factor of tested radioactive waste waters is about 10^4 when this waters are contacted in fixed bed with Purolite NRW 1600 resin.

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