

[54] **DECONTAMINATION PROCESS FOR
RADIO-ACTIVE LIQUIDS**

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[56]

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[57]

ABSTRACT

Radio-active liquids and the products thereof are decontaminated by contacting the radio-active liquid with a sorbent in a sulfate-containing medium selected from the group consisting of a barium salt and a barium salt mixed with up to 50 percent of a metal ferrocyanide.

13 Claims, No Drawings

DECONTAMINATION PROCESS FOR RADIO-ACTIVE LIQUIDS

This is a continuation-in-part of application Ser. No. 174,504, filed Aug. 24, 1971, now abandoned.

Heretofore it has been proposed to purify radio-active liquids with the help of ion exchangers, however, ion exchangers are expensive so that they have to be regenerated, which regeneration gives rise to further radioactive liquids (regeneration liquids).

Another known process for the treatment of radio-active liquids involves the chemical co-precipitation of the radio-active ions. The precipitate obtained is then filtered and homogeneously mixed with hot bitumen, during which step the water present evaporates, and the mass thus obtained is then stored in steel drums. As the precipitates cannot easily be filtered, large filtering installations are needed, or otherwise the precipitate must be dehydrated according to the "frost-thaw" method in order to make it more filterable.

All these methods furthermore have the disadvantage that they are not specific for radio-active ions, so that the ion exchangers tend to become largely saturated by ions which it is not desired to extract (such as Na, Ca or Mg), or that the precipitate consists largely of ions which it is not desired to extract, such ions being always present in the water to be purified.

The object of this invention is to provide a new method that is specific for radio-active ions, and at the same time allows the disadvantages of the methods already known to be at least partly avoided.

The present invention pertains to a method for extracting radio-active ions present in tracer quantities in a contaminated liquid, in which the liquid is contacted with a sorbent in a sulfate-containing medium selected from the group consisting of a barium salt, and a barium salt mixed with a metal ferrocyanide.

Ions such as Na, Ca, Mg, Fe, Al, thus are not extracted, while the radio-active ions are extracted from the liquids to be purified.

As a matter of fact, experiments have shown that different inorganic substances have specific sorption characteristics when they are brought into contact with solutions containing radio-active ions and more particularly ions in tracer quantities.

The term "sorption" as used in this specification includes any and every means by which an ion can be transferred from a solution to a solid mineral substance in contact with the solution.

The sorption may be achieved by, for example, one or more of isotopic exchanging, formation of mixed crystals, and more particularly precipitation, co-precipitation and post-precipitation.

The problem of the purifying of radio-active liquids lies particularly in the extraction of the following ions: strontium, cesium, cerium, cobalt, ruthenium, radium and antimony.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention will be hereafter described with the help of a number of tests and various examples.

Barium sulfate

BaSO₄ is prepared by mixing, at room temperature, equal volumes BaCl₂ and Na₂SO₄; the precipitate thereby formed is filtered and, without being washed, dried at 100°C. The powder thus formed is used for determining the sorption characteristics, expressed by the

distribution coefficient "Kd", which is defined as the ratio of the concentration of the ion on the sorbent (per gram) to the concentration of the ion in the solution (per ml). The experiments were carried out with demineralized water to which the radio-active ions to be determined, and 40 ppm Ca, were added. The Kd's obtained are for Sr = 7, for Ra = 27 and for Ce = 284.

After addition of H₂SO₄ to the test water, for instance to lower the pH to 2, the Kd values increase to the following values for Sr = 1950, for Ra = 3000 and for Ce = 6600.

The sorption mechanism may be deduced from these facts. If pure BaSO₄ itself had sorption properties, there would be no difference in the Kd values before and after the addition of H₂SO₄. However, this addition is necessary to achieve good sorption. On the other hand, as can easily be proved with the help of a reference solution, the sulfate ions in the solution, originating from the added H₂SO₄, are insufficient to reduce the solubility product of Sr and Ra, in order to precipitate them as tracers.

The reason why Sr and Ra are more effectively sorbed after the addition of H₂SO₄ is probably due to the co-precipitation phenomenon on newly formed BaSO₄. Indeed, barium ions still present in the prepared BaSO₄ (not washed out during the preparation) form, together with the sulfate ions in the solution, a supplementary BaSO₄ precipitate on the already existing solid BaSO₄. During this formation, strontium, radium and cerium are co-precipitated.

The Kd values can be considerably increased by preparing BaSO₄ as above, but with a surplus of barium ions. The Kd values thus obtained are summarized in Table 1. Furthermore, it is possible to increase the sorption properties of BaSO₄ by activating it, for instance by adding NaNO₃ during preparation of the BaSO₄. The concentration of NaNO₃ to be used will be such that there is the range from 1 Na ion for 1 Ba ion to 1 Na ion for 24 Ba ions.

Other concentrations of NaNO₃ do not favorably influence the sorption capacity of BaSO₄.

TABLE 1

Sorption of Sr, Ra and Ce on BaSO ₄				
Test water = demineralized water containing Sr, Ra and Ce and 40 ppm Ca to which H ₂ SO ₄ is added till a pH = 2 is obtained				
Composition BaSO ₄	Kd			
	Sr	Ra	Ce	Ca
*Ba/SO ₄ 1/1	7	27	284	0
Ba/SO ₄ 1/1	1.950	3.000	6.600	120
Ba/SO ₄ 2/1	14.000	28.000	45.000	160
Ba/SO ₄ 3/1	27.400	39.000	70.000	160
**Ba/SO ₄ 3/1	45.300	73.000	194.000	180

*Test water without addition of H₂SO₄

**BaSO₄ activated by addition of 1 volume NaNO₃ to 3 volumes BaCl₂ during the preparation of BaSO₄

As shown before a surplus of Ba ions in the BaSO₄ sorbent is necessary for good sorption properties. While a ratio of 3 Ba ions to 1 SO₄ ion gives good sorption, it must be noted that still higher proportions of Ba ions no longer improve the sorption properties.

Furthermore, it should be said that this co-precipitation is very selective and for instance practically no precipitate of calcium is obtained, as shown in Table 1. Analogous experiments with demineralized

water, to which sodium and magnesium ions were added, show that these ions are not co-precipitated.

From the above considerations it appears that the co-precipitation takes place during the formation of freshly formed BaSO_4 . It is to be noted that fresh BaSO_4 could also be formed starting from any soluble barium salt by the addition of SO_4 ions. Good results have been obtained with BaCO_3 in a sulfate medium. Thus, fresh BaSO_4 is formed and the co-precipitation of strontium, radium, cerium is achieved. With the same test water, the sorption on BaCO_3 has been carried out in the same acid conditions ($\text{pH} = 2 - \text{H}_2\text{SO}_4$) as for BaSO_4 , and then in a Na_2SO_4 medium. The K_d 's obtained are summarized in Table 2.

TABLE 2

Sorption of Sr, Ra and Ce on BaCO_3
Test water = demineralized water containing Sr, Ra and Ce and 40 ppm Ca by $\text{pH} = 2$ obtained in a medium as given in column 2.
 BaCO_3 = commercially available

Composition sorbent	Medium	Kd			
		Sr	Ra	Ce	Ca
BaCO_3	H_2SO_4	300	9.800	8.200	40
BaCO_3	0.01N Na_2SO_4	3.500	11.050	52.000	100
BaCO_3	0.01N Na_2SO_4	30.300	38.700	70.000	230

This table shows that in a medium of 0.1 N Na_2SO_4 the results of sorption on BaCO_3 are comparable with those of BaSO_4 in a molar ratio of Ba/SO_4 equal to 3/1.

As it is not always economical to handle large volumes of effluents in a medium of 0.1 N Na_2SO_4 it is proposed according to the invention to handle said volumes in an ion exchanger and to treat the regeneration liquids subsequently obtained from said ion exchanger with BaCO_3 .

It should be noted that ruthenium and antimony will also be sorbed on BaCO_3 .

To facilitate industrial use of these products, however, they should preferably have a structure which facilitates their use in industrial apparatus, for example columns, or mixer settlers. Barium sulfate and barium carbonate however are obtained as a fine powder and as such are unsuitable for use in industrial columns.

According to another feature of the invention, a suitable structure can be imparted to BaSO_4 by preparing it as a mixed salt with a metal ferrocyanide. For instance, BaSO_4 and $\text{Cu}_2\text{Fe}(\text{CN})_6$ prepared as a mixed substance has a good granular structure and can be used to extract at the same time strontium, radium and cerium as well as cesium, ruthenium and antimony.

The following example gives a preferred method of preparation of this mixed substance : 300 volumes 1 molar Na_2SO_4 are added to 150 volumes 0.1 molar CuSO_4 . While stirring, 945 volumes 1 molar BaCl_2 are added to this mixture. 75 volumes 0.1 molar $\text{K}_4\text{Fe}(\text{CN})_6$ are then added to the obtained precipitate of BaSO_4 and vigorously stirred for 2 minutes. The precip-

itate is then allowed to form for 1 or 2 hours before being filtered. Without being washed, the precipitate is then dried at 100°C . The cake thus obtained is then ground into grains of the required size (larger than 80 mesh in this example). The theoretical composition of said grains is 97.7 % BaSO_4 with a molar ratio Ba/SO_4 of 3/1, and 2.3 % $(\text{Cu}_2\text{Fe}(\text{CN})_6)$ with a molar ratio $\text{Cu}_2/\text{Fe}(\text{CN})_6$ of 1/1. Said grains are then placed in a column, through which test water is poured.

The K_d values obtained are given in Table 3.

The same example is repeated, but NaNO_3 is added in a ratio of 3 Ba ions for 1 Na ion.

The same example is repeated but NaNO_3 is replaced by CaCl_2 in a ratio of 3 Ba ions for 1 Ca ion.

TABLE 3

Sorption of Sr, Ce and Cs on mixed sorbent $\text{BaSO}_4/\text{Cu}_2\text{Fe}(\text{CN})_6$					
Test water = demineralized water containing Sr, Ra, Ce and Cs, 100 ppm Na and 30 ppm Cu, to which H_2SO_4 is added till a $\text{pH} = 2$ is obtained					
Mixed sorbent	Activation	Kd			
		Sr	Ce	Cs	
97.7 % BaSO_4 / 2.3% $\text{Cu}_2\text{Fe}(\text{CN})_6$	Nil	2.560	7.850	32.100	
	NaNO_3 : $\text{Na}/\text{Ba} = 1/3$	15.800	45.000	55.000	
	CaCl_2 : $\text{Ca}/\text{Ba} = 1/3$	9.150	31.500	63.750	

K_d for Ra has not been determined

These examples clearly show the importance of the activation of the sorbents.

Another sorbent which could be used according to the present invention is BaCO_3 and $\text{Cu}_2\text{Fe}(\text{CN})_6$. Contrary to the above-mentioned mixed product containing BaSO_4 , this mixed salt based on BaCO_3 is still a fine powder so that the contact between the mixed product and the effluents to be treated will have to be carried out in batches. The sorbent can, for example, be prepared as follows.

On the one hand, one volume 1 molar BaCl_2 is added to one volume 1 molar Na_2CO_3 and allowed to precipitate homogeneously. On the other hand, one volume 0.1 molar $\text{K}_4\text{Fe}(\text{CN})_6$ is added to two volumes 0.1 molar CuSO_4 and allowed to precipitate homogeneously. Both precipitates are mixed, stirred and dried without being washed. This preparation results in a mixed sorbent comprising 91 % BaCO_3 with a molar ratio Ba/CO_3 of 1/1 and 9 % $\text{Cu}_2\text{Fe}(\text{CN})_6$ with a molar ratio $\text{Cu}_2/\text{Fe}(\text{CN})_6$ of 1/1. The K_d 's on this sorbent are determined with the same test water as used in Table 3 and given hereafter in Table 4.

The $\text{pH} = 2$ was obtained in a medium as given in column 2. (5 g sorbent was mixed with 1 liter solution for 15 mins. and then centrifuged).

TABLE 4

Composition sorbent	Medium	Kd		
		Sr	Ce	Cs
91 % BaCO_3 and 9 % $\text{Cu}_2\text{Fe}(\text{CN})_6$	H_2SO_4	1.120	17.720	12.500
	0.01N Na_2SO_4	8.630	56.200	30.700
	0.1N Na_2SO_4	20.460	59.600	77.000

It should be noted that ruthenium, antimony and cobalt will also be sorbed on this sorbent. Further examples will illustrate the results obtained. This table shows the excellent results obtained in a medium of 0.1 N Na_2SO_4 . As already stated in the specification, it is not always economical to handle large volumes of effluents in a medium of 0.1 N Na_2SO_4 . It is therefore proposed according to the invention to treat the effluents with ion exchangers and to treat regeneration liquids subse-

quently obtained from the ion exchangers with this sorbent.

As the sorbent is effective in a concentrated salt solution, it will present an answer to the problem for decontamination of regeneration liquids of ion exchangers.

It is to be noted that ion exchangers have been proposed several times for decontaminating radio-active liquids. However, up to now they have not been practical because of the problems raised by the decontamination of their regeneration liquids, which in fact are effluents with radio-active ions in a concentrated salt solution. With the help of mixed $\text{BaCO}_3 - \text{Cu}_2\text{Fe}(\text{CN})_6$ sorbent, these regeneration waters can be simply and effectively treated without further problems.

The sorbent is used in a sulfate medium if strontium is present in the effluents to be treated. As a matter of fact, it has been found that the sulfate concentration influences the sorption of the different radio-active ions. Table 5 shows the influence of the sulfate concentration while using the above described $\text{BaCO}_3 - \text{Cu}_2\text{Fe}(\text{CN})_6$ sorbent. The test water contained a concentration of 2 molar NaCl and 0.05 molar CaCl_2 and traces of Cs, Sr, Ce, Ra, Co, Ru and Sb. 3 g. sorbent were added to 1 liter test water and mixed for one hour before filtration.

TABLE 5

Ions present in regeneration liquid in trace amounts	Percentage of sorption with a sulfate concentration					
	0.01 N	0.025 N	0.05 N	0.1 N	0.125 N	0.15 N
cesium	99.0 %	99.3 %	99.5 %	99.5 %	99.2 %	99.5 %
strontium	36.5 %	80.0 %	94.1 %	97.0 %	97.7 %	98.0 %
cerium	98.5 %	98.9 %	99.3 %	99.5 %	99.2 %	99.3 %
radium	97.0 %	97.2 %	97.6 %	97.4 %	97.6 %	97.3 %
cobalt	94.2 %	93.4 %	93.1 %	95.3 %	95.1 %	94.7 %
ruthenium	96.4 %	97.1 %	97.5 %	97.0 %	97.1 %	96.8 %
antimony	97.2 %	97.9 %	97.8 %	97.9 %	97.8 %	98.0 %

This table shows clearly that the sorption of Sr especially is a function of the sulfate concentration. A concentration of 0.1N Na_2SO_4 is preferred because higher concentrations could give rise to the formation of CaSO_4 . Furthermore, it should be noted that carbonates are generally soluble in an acid medium, so that a pH higher than 3.5 is indicated. Although the above described experiments have been carried out with a mixed sorbent comprising 91 % BaCO_3 and 9 % $\text{Cu}_2\text{Fe}(\text{CN})_6$, other proportions of these salts could be used. Table 6 shows the sorption of radio-active ions on $\text{Cu}_2\text{Fe}(\text{CN})_6$ on one side, BaCO_3 on the other side and a mixture of 91 % BaCO_3 and 9 % $\text{Cu}_2\text{Fe}(\text{CN})_6$. The test water comprised 2 molar NaCl and 0.2 molar CaCl_2 in addition to Cs, Sr, Ce, Ra, Co, Ru and Sb. Na_2SO_4 was added up to 0.1 N and the sorbent was added in a proportion of 7 g. sorbent per litre of water.

TABLE 6

Traced Isotope	$\text{Cu}_2\text{Fe}(\text{CN})_6$	Percentage Decontamination	
		BaCO_3	91 % BaCO_3 & 9 % $\text{Cu}_2\text{Fe}(\text{CN})_6$
Cesium	96.07 %	26.11 %	99.77 %
Strontium	12.00 %	86.79 %	95.05 %
Cerium	63.10 %	99.42 %	99.76 %
Radium	75.30 %	97.57 %	99.64 %
Cobalt	23.20 %	47.49 %	94.60 %
Ruthenium	98.08 %	96.81 %	98.90 %
Antimony	98.33 %	98.69 %	98.90 %

This table shows that Ru and Sb are sorbed by both components, while Cs is sorbed mainly by $\text{Cu}_2\text{Fe}(\text{CN})_6$.

Ce and Ra, on the other hand, are sorbed mainly by BaCO_3 . The proportion of the mixed sorbent should especially be considered for the sorption of Sr and Co. It has been found that for a good sorption of Sr at least 90 % of BaCO_3 should be present in the mixed sorbent.

As far as Co is concerned, the same proportion gives good results, but could still be increased to a proportion of 85 % BaCO_3 and 15 % $\text{Cu}_2\text{Fe}(\text{CN})_6$. However, in view of the radiological toxicity of Sr, a mixed sorbent comprising at least 90 % BaCO_3 is preferred to ensure sorption of the maximum amount of Sr.

It is clear that the proportion of these salts will be adapted by the man skilled in the art in function of the liquids to be decontaminated. If only Cs, Ru and Sb are to be extracted, the mixed sorbent may contain large proportions of metal ferrocyanide. However, the mixed sorbent will contain generally at least 50 percent of the barium salt and preferably at least 85 percent.

Further examples of the sorption of radio-active ions present in the regeneration liquids of ion exchangers used for decontaminating radioactive effluents are described hereafter.

An effluent containing the following metal ions B 2 ppm, Mn 0.16 ppm, Fe 0.2 ppm, Mg 1.15 ppm, Si 2.55 ppm, Ca 41 ppm, Na 112 ppm, Sr 0.06 ppm, and K 6.4 ppm, in addition to following isotopes Ce^{144} , Ru^{106} ,

Cs^{137} , Zr^{95} , Nb^{95} , Co^{58} , Co^{60} , Mn^{54} , and Sr^{90} , was poured at a pH = 3 through a column containing a synthetic ion exchanger in the sodium form (amberlite IR-120). After having passed 350 volumes of said effluent, the water was decontaminated to the following extent.

Sr^{90}	=	99.7 %
Ru^{106}	=	95.6 %
Cs^{137}	=	94.1 %
Co^{58}	=	100 % and Co^{60} = 98.3 %
Ce^{144}	=	100 %
Zr^{95}	+	Nb^{95} = 100 %
Mn^{54}	=	100 %

The ion exchanger was then regenerated with seven volumes of 4 molar NaCl . The pH of the regeneration liquid is raised to 3.5 and Na_2SO_4 is added up to 0.1N. 10 g. of the mixed sorbent 91 % BaCO_3 - 9 % $\text{Cu}_2\text{Fe}(\text{CN})_6$

$\text{Fe}(\text{CN})_6$ are added to 1.5 liters of this effluent, stirred for 1 hour and centrifuged for 10 minutes. The water

was tested and found to be decontaminated for 95.1 % gamma decontamination, 98.7 % beta decontamination, and as far as Sr^{90} is concerned, 98.6 % was decontaminated.

A further effluent containing following metal ions B 1 ppm, Mn 0.09 ppm, Fe 1.3 ppm, Mg 0.9 ppm, Si 2 ppm, Al 1.95 ppm, Ca 61.5 ppm, Na 38 ppm, Sr 0.1 ppm and K 6.5 ppm, in addition to following isotopes Ce^{144} , Ru^{106} , Cs^{137} , Zr^{95} , Nb^{95} , Co^{58} , Co^{60} , Mn^{54} and Sr^{90} was poured through a column containing the same ion exchanger as in the preceding example. After having passed 625 volumes of said effluent, the water was decontaminated for 94.8 % gamma-beta-decontamination and for 97.8 % Sr^{90} decontamination.

The ion exchanger was then regenerated with 12.5 volumes of 2 molar NaCl. The pH of the regeneration liquids was raised to 6.5 with the addition of NaOH, and Na_2SO_4 was added up to 0.1 N. 10 g. of the mixed sorbent 91 % BaCO_3 - 9 % $\text{Cu}_2\text{Fe}(\text{CN})_6$ were added to 2 liters of this effluent, stirred for one hour and filtered. The water was tested and found to be decontaminated for 97.7 % gamma-beta-decontamination, and for 99.8 % Sr^{90} decontamination. This last example shows that the Sr^{90} decontamination was more effective with a pH = 6.5.

Other ions for example U, Pu, I, Zr, Nb and Mn can also be sorbed by the method of the invention.

The method according to the invention is particularly effective when the mixed salt is a mixture of a barium salt and a metal ferrocyanide. BaSO_4 or BaCO_3 are preferably used as barium salts.

As metal ferrocyanides, especially copper ferrocyanide, manganese ferrocyanide, cobalt ferrocyanide, nickel ferrocyanide and zinc ferrocyanide are to be considered

A ferrocyanide with different metal ions can also be used.

Different experiments have been made, in which the test water to be purified contained a concentration of 2 molar NaCl and 0.05 molar CaCl_2 , as well as traces of Cs, Sr, Ce, Ra, Co, Ru and Sb. 3 g sorbent were added to 1 liter test water and mixed for an hour before filtration. The values obtained are shown in Table 7, the mixed salts mentioned herein are composed as follows:

- a = 9 % $\text{Cu}_2\text{Fe}(\text{CN})_6$ / 91 % BaCO_3
- b = 9 % $\text{Mn}_2\text{Fe}(\text{CN})_6$ / 91 % BaCO_3
- c = 9 % $\text{Ni}_2\text{Fe}(\text{CN})_6$ / 91 % BaCO_3
- d = 9 % $\text{CO}_2\text{Fe}(\text{CN})_6$ / 91 % BaCO_3
- e = 9 % $\text{Zn}_2\text{Fe}(\text{CN})_6$ / 91 % BaCO_3

The sorbents are all prepared in the same way from metal sulfates, BaCl_2 , Na_2CO_3 and $\text{K}_4\text{Fe}(\text{CN})_6$.

The sorbent is used in a sulfate medium with a concentration of 0.1 N Na_2SO_4 .

TABLE 7

Radio-active ions	Sorbent				
	a	b	c	d	e
cesium	99.6 %	99.8 %	99.5 %	99.7 %	53.0 %
strontium	96.7 %	96.4 %	96.3 %	97.5 %	96.2 %
cobalt	95.3 %	99.1 %	91.2 %	82.7 %	72.0 %
ruthenium	96.0 %	92.8 %	97.5 %	96.7 %	97.0 %
antimony	99.4 %	99.4 %	99.4 %	99.3 %	99.6 %

radio-active ions sorbed

The experiments show that a mixed salt with copper ferrocyanide gives good results, and that good results can also be obtained with a mixed salt containing manganese ferrocyanide. The starting substance for the

preparation of manganese ferrocyanide is MnSO_4 , which, like CuSO_4 , is a very cheap product. A mixed barium salt containing manganese ferrocyanide can thus advantageously be used as sorbent for radio-active ions generally contained in contaminated water.

The mixed salt with zinc ferrocyanide does not give as good results as with copper ferrocyanide for the sorption of cesium and cobalt, but it can be used for the sorption of strontium, ruthenium and antimony.

Cobalt and nickel salts also give good results, but since they are expensive, their value is more theoretical than practical.

It is evident that this invention may be used in many different ways and for many different applications by a man skilled in the art.

We claim:

1. A method for extracting radioactive ions present in tracer quantities from a contaminated liquid which comprises contacting said liquid with a mixed sorbent of an insoluble barium salt selected from the group consisting of barium sulfate and barium carbonate, mixed with up to 50 percent of a metal ferrocyanide in a sulfate-containing medium.

2. The method of claim 1 wherein the barium salt is barium sulfate and has a ratio of 3 barium ions to 1 sulfate ion.

3. The method of claim 1 wherein sodium nitrate is added to the barium sulfate in an amount such that the resulting mixture has 1 sodium ion for from 1 to 24 barium ions.

4. The method of claim 1 wherein said mixed sorbent contains at least 2 percent metal ferrocyanide.

5. The method of claim 4 wherein the metal ferrocyanide is copper ferrocyanide, manganese ferrocyanide, cobalt ferrocyanide, nickel ferrocyanide or zinc ferrocyanide.

6. The method of claim 5 wherein the sorbent is from 85-98 percent barium salt which has an excess of barium cations and from 15-2 percent of a metal ferrocyanide in a sulfate-containing medium.

7. The method of claim 5 wherein said barium salt is barium sulfate having a ratio of 3 barium ions to 1 sulfate ion, and wherein said metal ferrocyanide is copper ferrocyanide having a ratio of 1 copper ion to 1 ferrocyanide ion in a sulfate-containing medium.

8. The method of claim 6 wherein said mixed sorbent is barium carbonate and copper ferrocyanide in a sulfate-containing medium.

9. The method of claim 4 wherein said mixed sorbent additionally contains sodium nitrate in an amount such that there is one sodium ion for from 1 to 24 barium ions.

10. The method of claim 4 wherein said mixed sorbent additionally contains calcium chloride in an amount such that there is 1 calcium ion for from 1 to 20 barium ions.

11. The method of claim 4 wherein at least 90% of the mixed sorbent is barium carbonate.

12. The method of claim 1 wherein the contaminated liquids are the regeneration liquids from an ion exchanger previously used for decontaminating radioactive effluents.

13. The method of claim 4 wherein the contaminated liquids are the regeneration liquids from an ion exchanger previously used for decontaminating radioactive effluents.