Determination of ^{90}Sr in seawater for routine monitoring and emergency preparedness

01 May, 2017

Hyuncheol Kim

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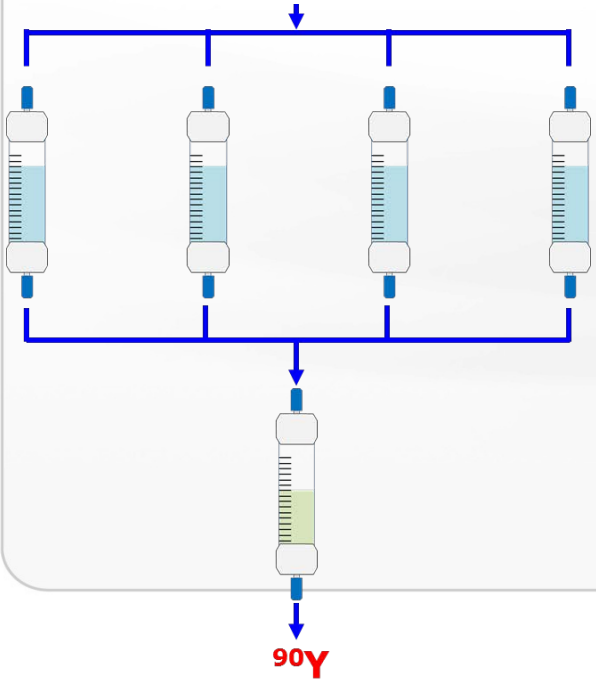
Normal

Emergency



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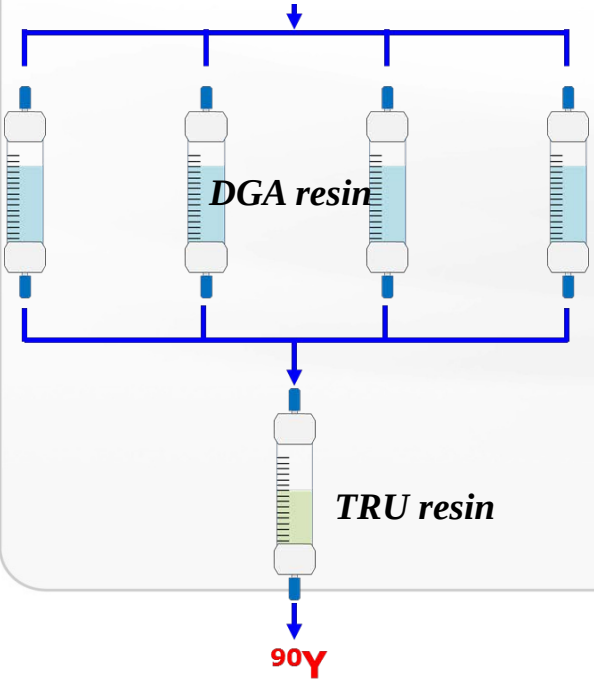

^{90}Sr in seawater

Normal | **Emergency**

Global average value : ~ 1 mBq/kg
(*Aoyama & Hirose*, 2004)

Coastal area in Korea: 0.4 – 1.1 mBq/kg
(KINS, 2015)

^{90}Sr in seawater

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Global average value : ~ 1 mBq/kg
(*Aoyama & Hirose*, 2004)

Coastal area in Korea: 0.4 – 1.1 mBq/kg
(KINS, 2015)

Volume Reduction !

^{90}Sr in seawater

Normal **Emergency**

Precipitation

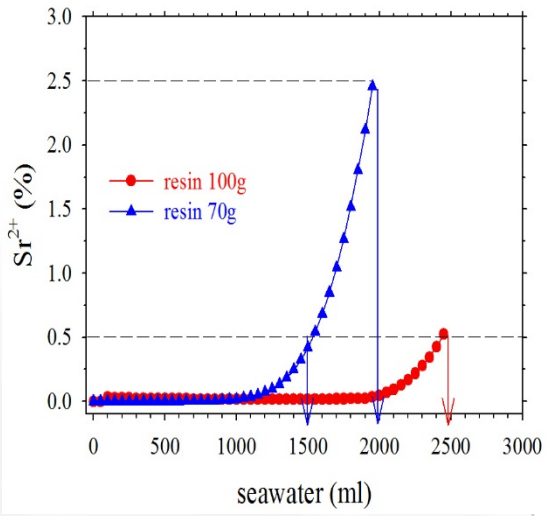
$SrCO_3 \downarrow$
Sr^{2+} / $Ca(OH)_2 \downarrow$
$Sr(NO_3)_2 \downarrow$
Sr^{2+} / $Ba(Ra)SO_4 \downarrow$

Sr^{2+} in seawater: ~ 8 mg/kg

^{90}Sr in seawater

Normal **Emergency**

Cation ex. resin



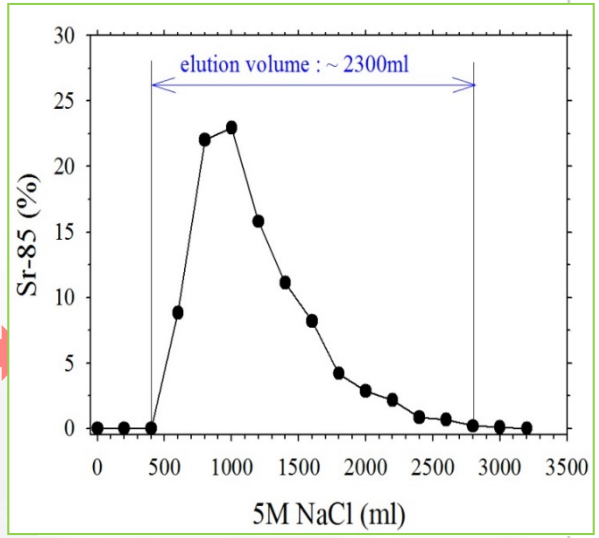
$R\text{-}SO_3{\cdot\cdot}M + Sr^{2+} \leftrightarrow R\text{-}SO_3{\cdot\cdot}Sr + M^{+}$

Dowex50Wx8 (400 g)
10 L of seawater
10 L → 2.3 L

^{90}Sr in seawater

Normal **Emergency**

Cation ex. resin



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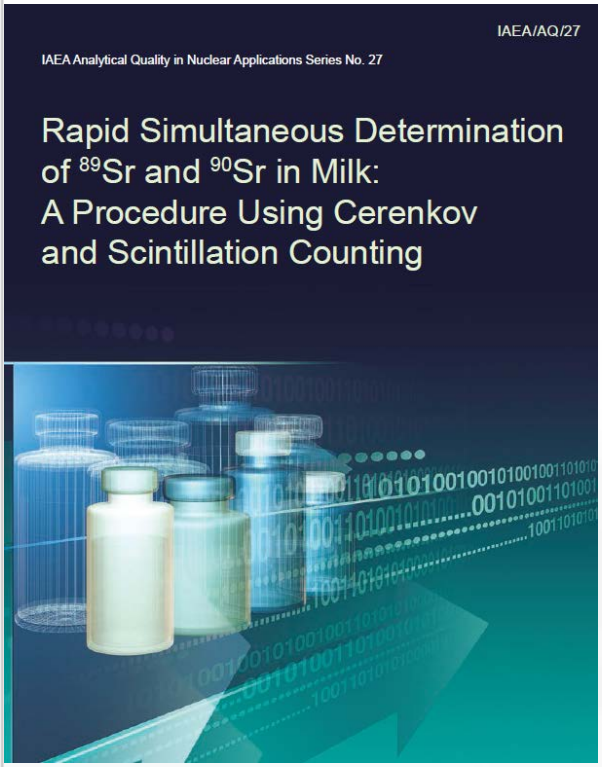

IAEA/AQ/27 (2013)

Milk 250 ml (or Milk Powder)
+ Cation ex. resin (30ml) + Sr resin (3g)

$SrCO_3$

(*Chung et al.* 2015)

^{90}Sr in seawater

Normal

Emergency

IAEA/AQ/27

IAEA Analytical Quality in Nuclear Applications Series No. 27

Rapid Simultaneous Determination of ^{89}Sr and ^{90}Sr in Milk: A Procedure Using Cerenkov and Scintillation Counting

ALMERA Analytical Method Development Activity: Validation of the Procedure for the Rapid Simultaneous Determination of ^{89}Sr and ^{90}Sr in Seawater Samples

Dear Mr Kim,

In the frame of the ALMERA analytical method development activities, the validation of the procedure for the rapid simultaneous determination of ^{89}Sr and ^{90}Sr in seawater samples is being organized following the development of a detailed procedure by an ALMERA expert group.

Following your expression of interest and selection for the validation phase, we are pleased to send you the validation sample set as well as the associated documentation.

The documentation consists of:

- This accompanying letter;
- The detailed procedure for the rapid simultaneous determination of ^{89}Sr and ^{90}Sr in seawater samples to be used in the frame of the validation phase;
- A reporting form,
- The procedure IAEA/AQ/27 "Rapid Simultaneous Determination of ^{89}Sr and ^{90}Sr in Milk: a Procedure Using Cerenkov and Scintillation Counting" (sent by email),

IAEA/AQ/27 (2013)

Milk 250 ml (or Milk Powder)
+ Cation ex. resin (30ml) + Sr resin (3g)

ALMERA method validation (2016)

seawater 100 ml $SrCO_3$ ↓ + Sr resin (2 ml)

^{90}Sr in seawater

Normal

IAEA/AQ/27

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IAEA/AQ/27 (2013)

Milk 250 ml (or Milk Powder)
+ Cation ex. resin (30ml) + Sr resin (3g)

Carbonate precipitate

ALMERA method validation (2016)

seawater 100 ml $SrCO_3$ ↓ + Sr resin (2 ml)

Object

More Simple Faster More Convenient

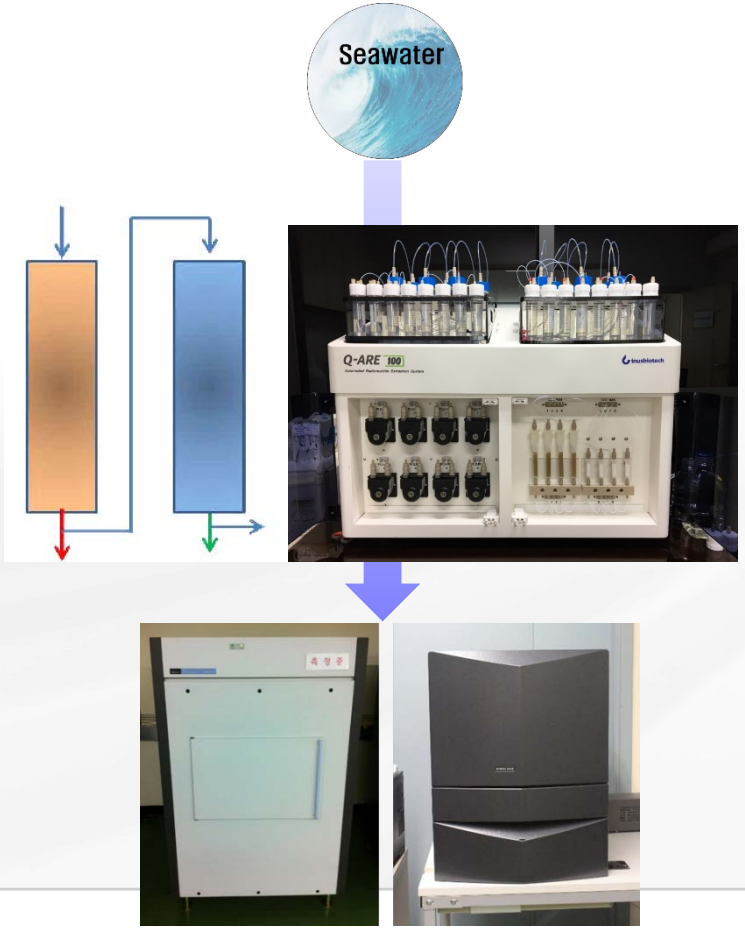
Pretreatment
(Concentration)

Groundwater
/Seawater

Chemical Separation
(Purification, separation from interferences)

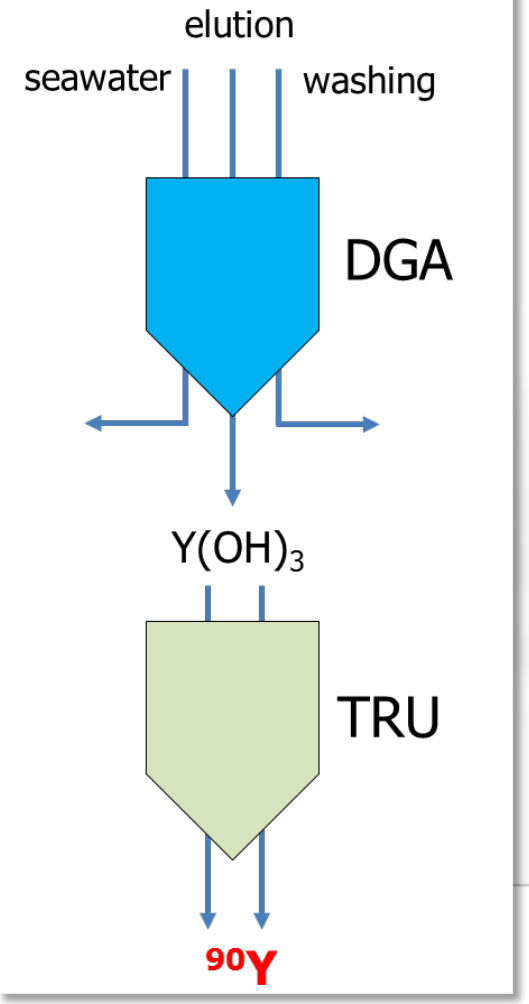
Separation of Ca, Ba, Ra, Pb, and Y

Analysis
(Liquid Scintillation Counter
Gas Proportional Counter)



^{90}Sr in seawater

Normal



Emergency

10-40 L

Seawater Sample
Acidify to ~pH 2 with 12M HCl (1 mL per L)
Add stable Y carrier (1mg)

Add 10 mg La to each aliquot. Add Fe (50 mg per L). Mix, add 14.5 M NH_4OH (1.75mL per L), mix, allow to settle, pour off supernate to ~2- 4L (pH= 8.8-9.0)

$Fe(OH)_3$ co-ppt

Transfer to four 500 mL centrifuge tubes
Centrifuge 10 minutes, discard supernate.
Rinse each ppt. with 100 mL water (pH 8.8-8.9).
Mix, centrifuge and discard supernate.

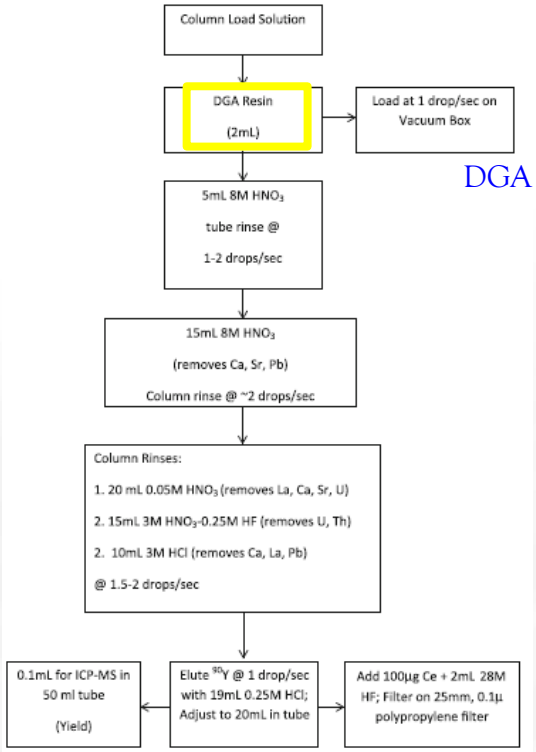
Add 100 mL 1.5M HCl to one tube, redissolve and transfer to 2nd tube, rinse first tube 2-3 times with 20 mL 1.5M HCl, Cap and mix

Add 75 mg Ca and 50 mL 28M HF, mix,
and allow to sit ~15 min.
Centrifuge and discard supernate.

$(Y/La)F_3$

Redissolve in 10 mL 3M HNO_3-0.25M Boric acid, 10 mL 15.8M HNO_3, 10 mL 2M $Al(NO_3)_3$

Column Load Solution

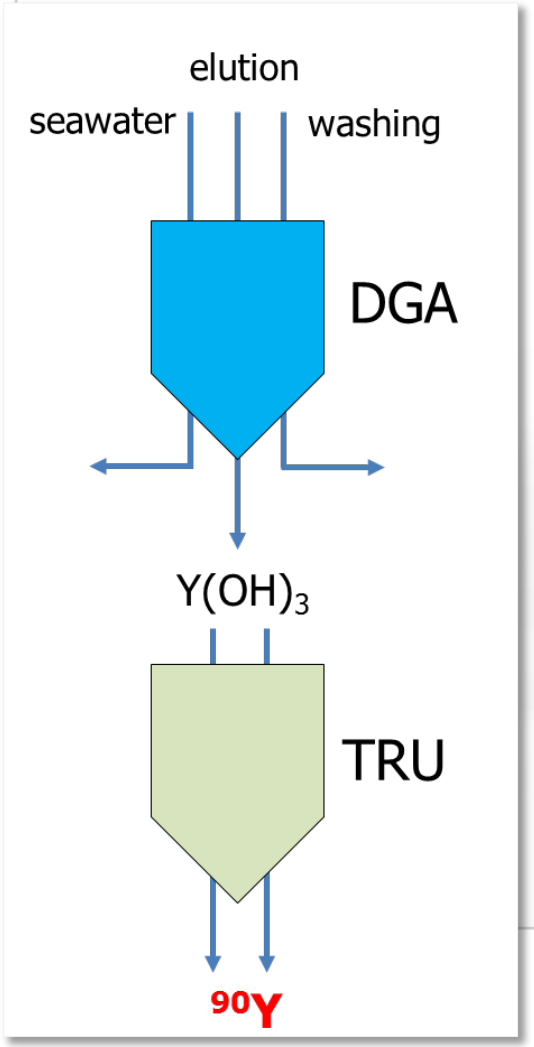


DGA reisn 2 ml

(*Maxwell et al. 2015*)

^{90}Sr in seawater

Normal



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Column Load Solution

Column Load Solution

Seawater samples 0.5-3L
(Acidified and achieving secular equilibrium of ^{90}Sr-^{90}Y)

0.5-3L

Fe (3 mg)
Y (0.1 mg)
NH_4OH
filtration

Precipitates

HNO_3 (5 mL)

Solutions

DGA 1ml

DGA Resin column
(50-100 µm)
bed volume=1mL
flow rate:
1 mL min^{-1} (sample load)
2 mL min^{-1} (rinse and strip)

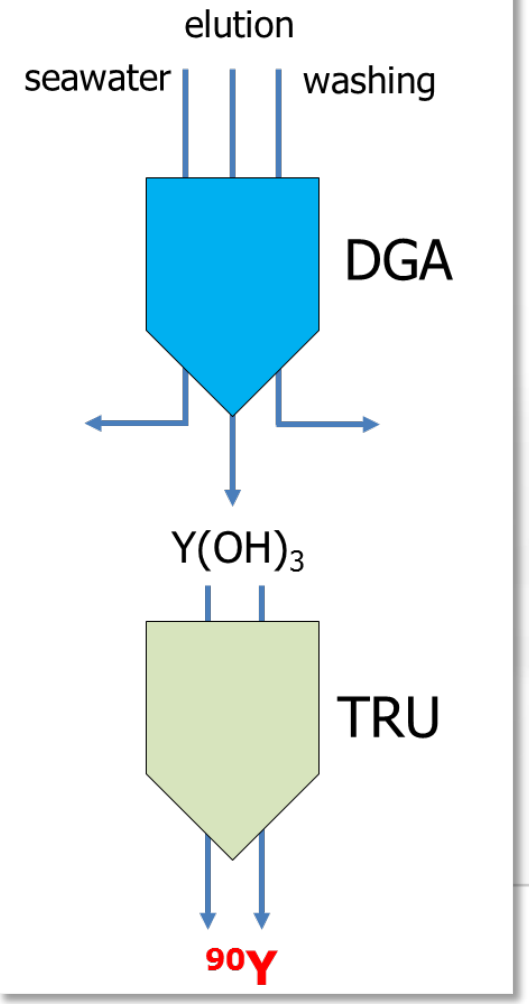
- 8 M HNO_3 15 mL
- 8M HCl 10 mL
- 3 M HNO_3+0.3 M HF 20 mL
- 0.02 M HNO_3 20 mL
- 0.1M HCl 20 mL

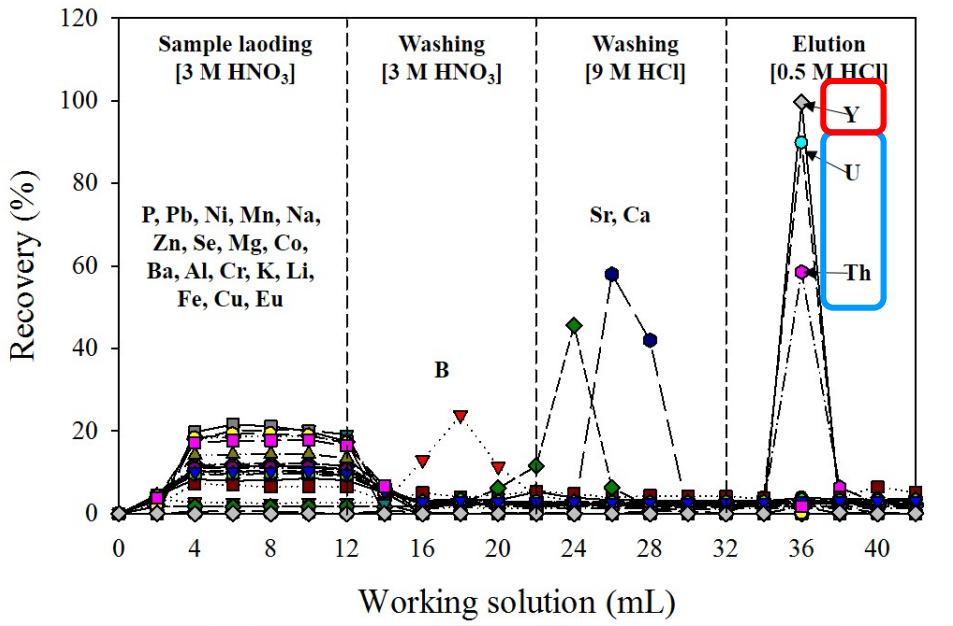
^{90}Y

(*Tazoe et al. 2016*)

^{90}Sr in seawater

Normal | **Emergency**



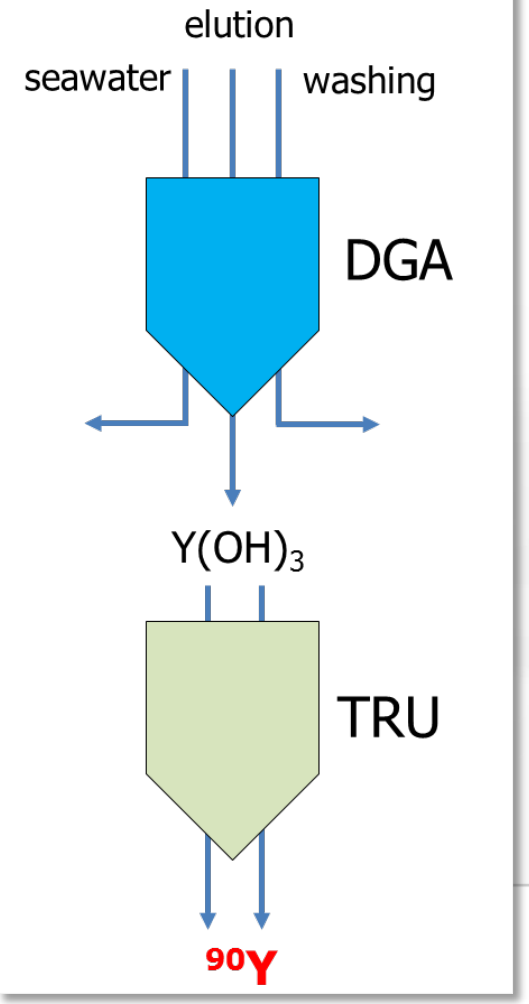


DGA resin 2 ml (BV)

(*Jung et al. under review*)

^{90}Sr in seawater

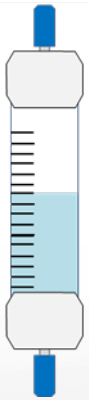
Normal



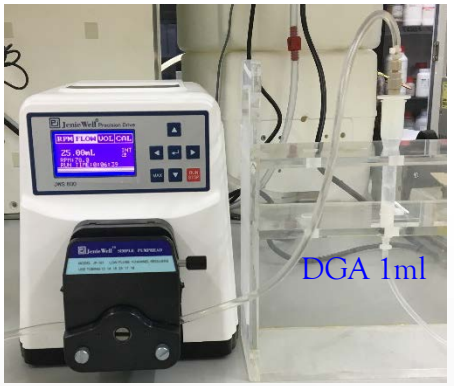
Emergency

2.5 L (seawater 2L + HNO_3)
Stable Y 5 mg, 25 ml/min

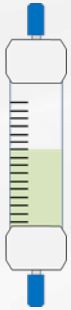
DGA 1ml(BV)
Recovery 75%

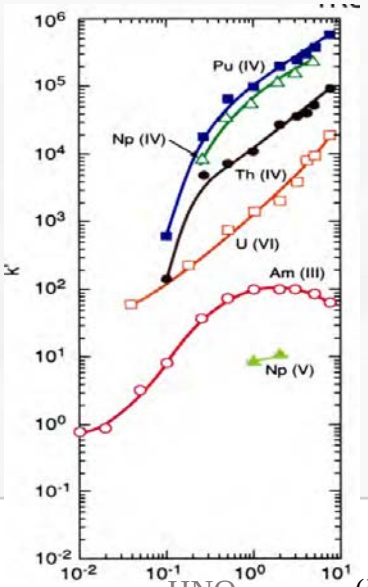


DGA 2ml(BV)
Recovery 98%



U & Th are strongly
retained on **TRU** resin.





^{90}Sr in seawater

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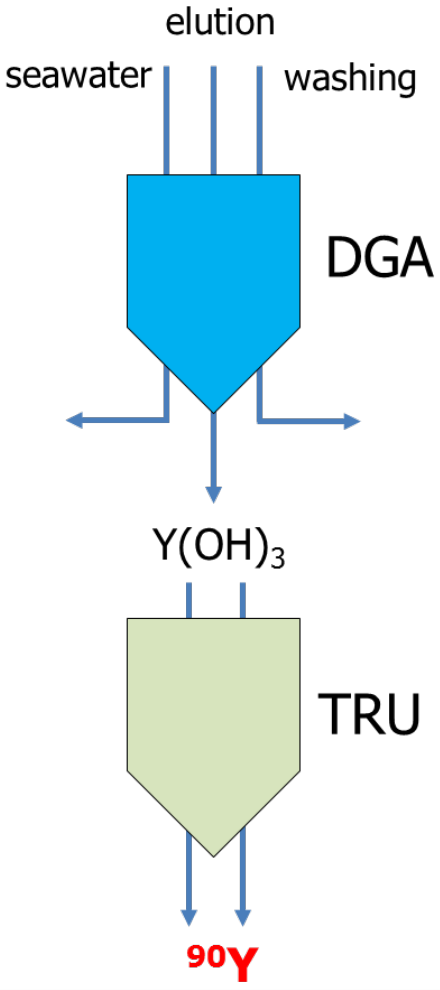


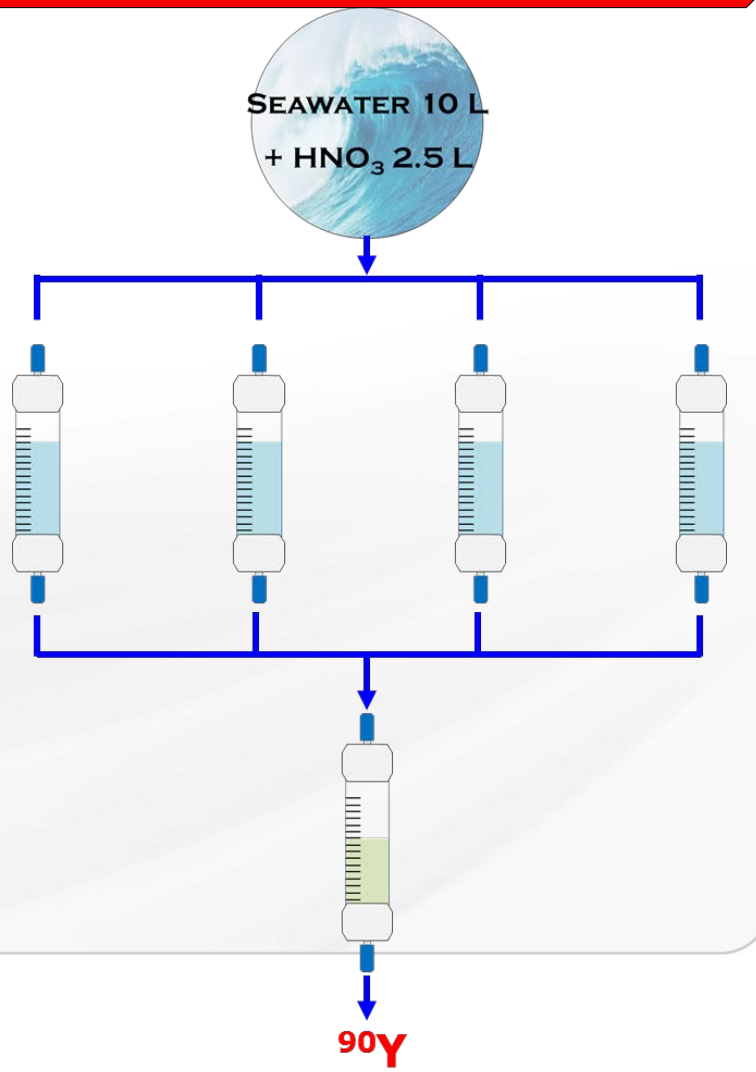
Emergency

12.5 L
(Seawater **10 L**+HNO_3)

DGA (2.5 ml, BV) x 4
W1: 3 M HNO_3 5 BV
W2: 9 M HCl 5 BV
E : 0.5 M HCl 5 BV

at pH 10,
Y(OH)3 ↓

TRU (2 ml, BV)
L : 3 M HNO_3 5 BV
W: 3 M HNO_3 5 BV



^{90}Sr in seawater

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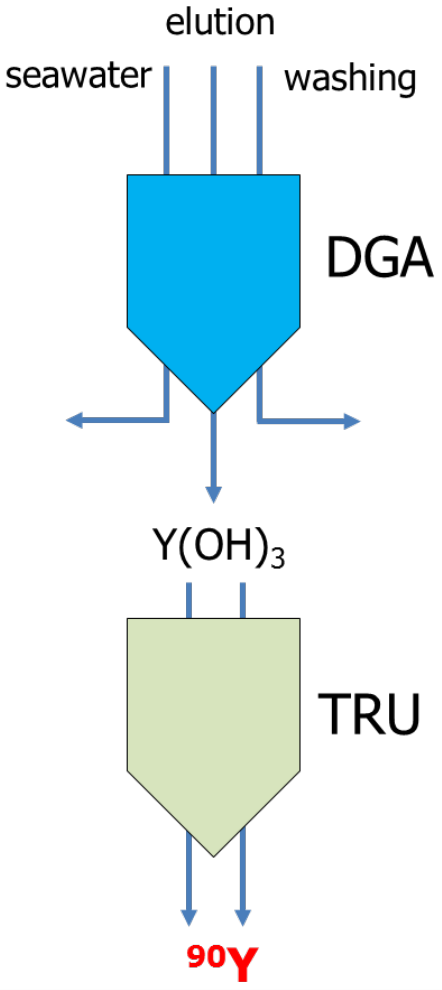
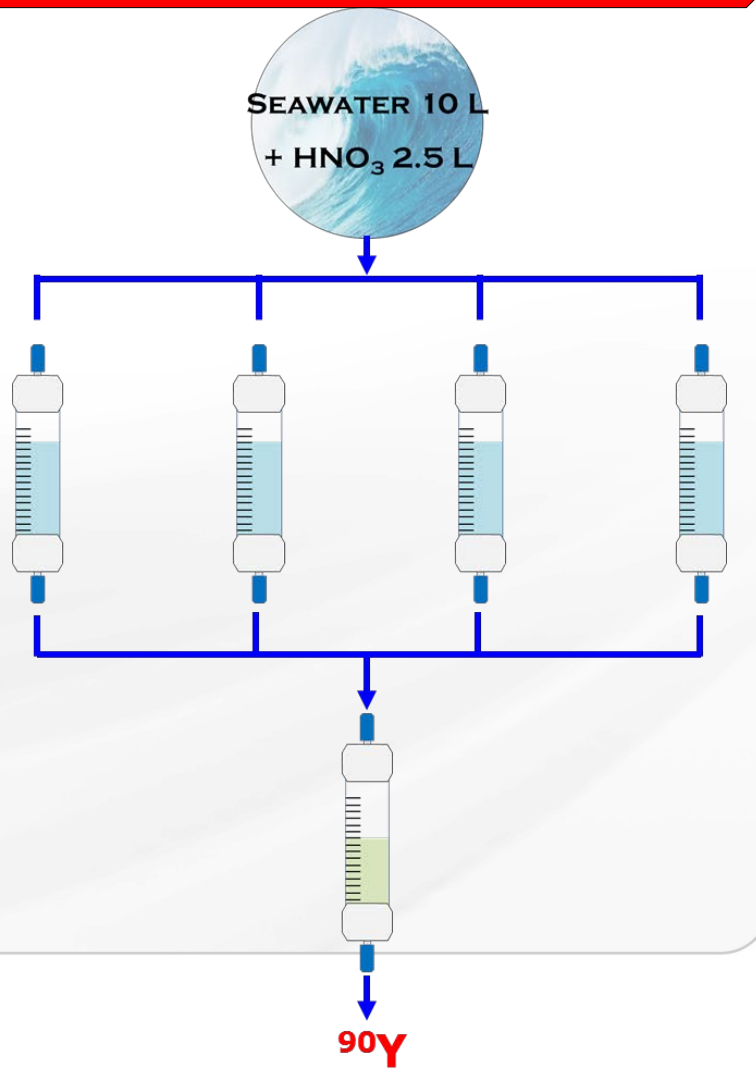


Result

Seawater	10 L
	(12.5 L)
DGA	2.5 ml(BV) x 4
Stable Y	5 mg
Recovery Y	80 %
Relative error	5 %
Time	3 h
	(with four pump)
Flow rate	25 ml/min

Emergency



^{90}Sr in seawater

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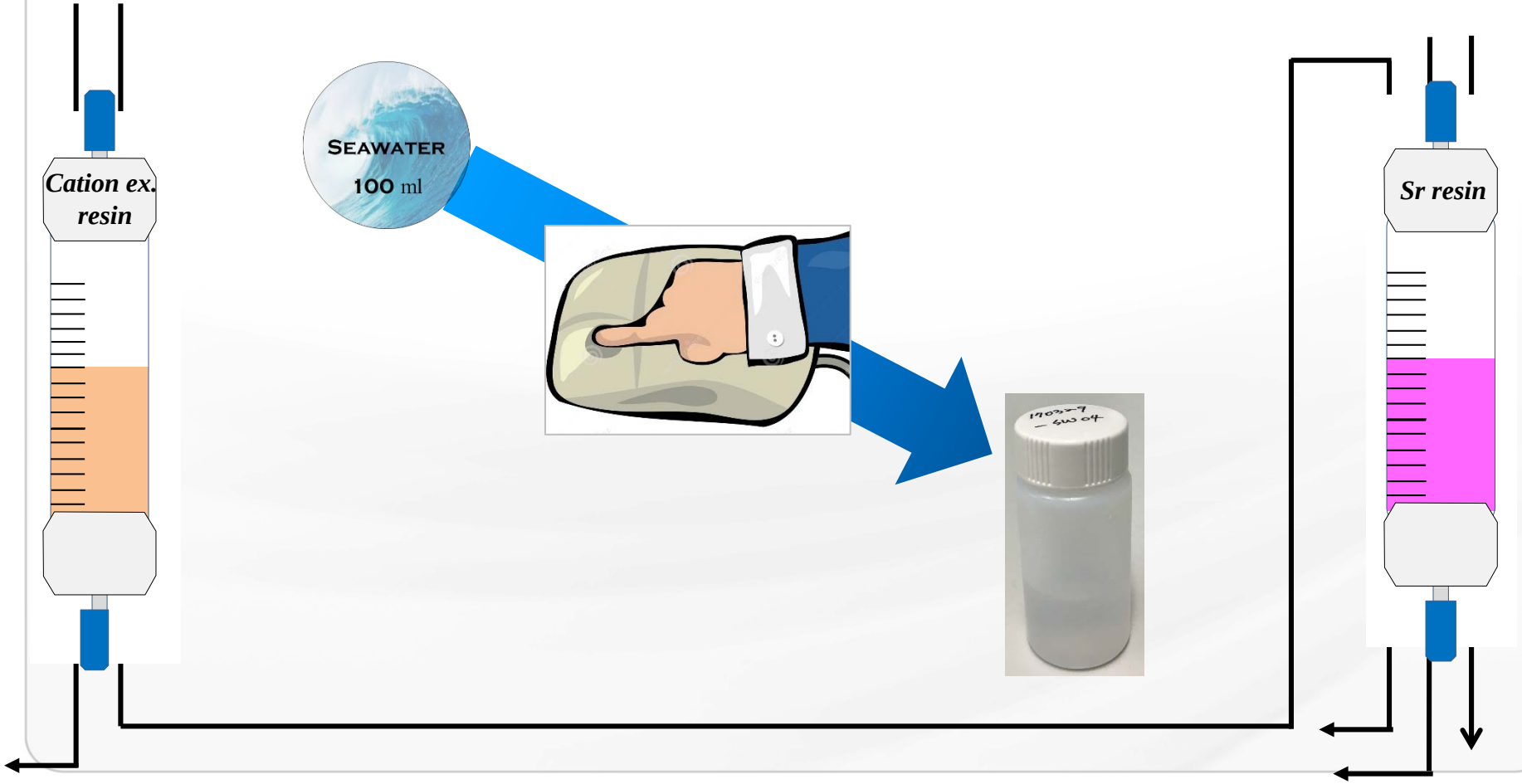

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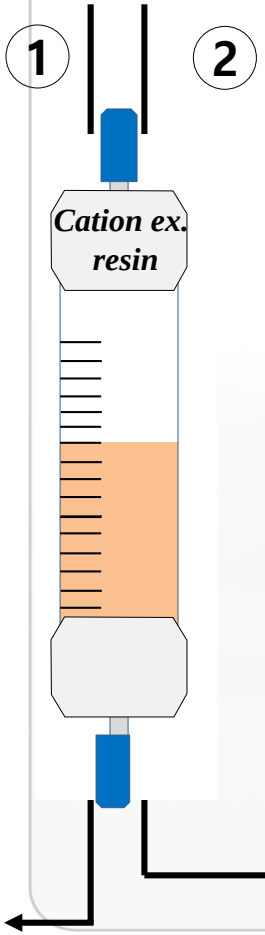

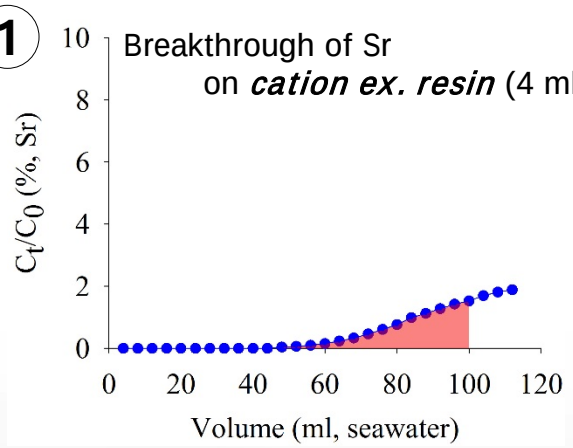

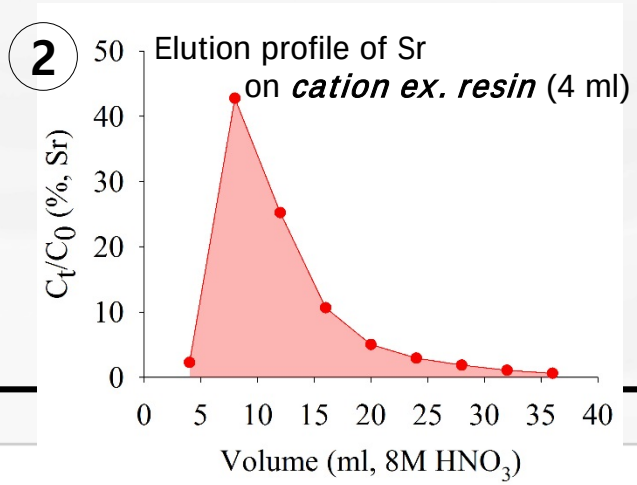

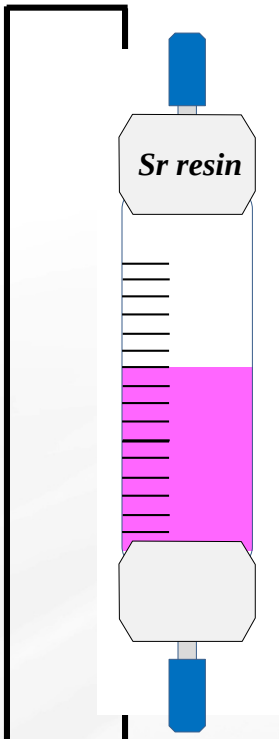

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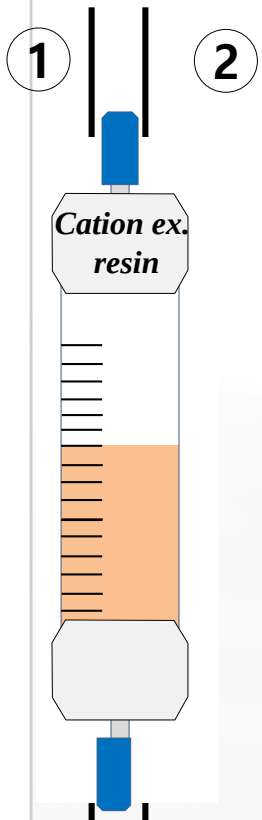


Seawater: 100 ml

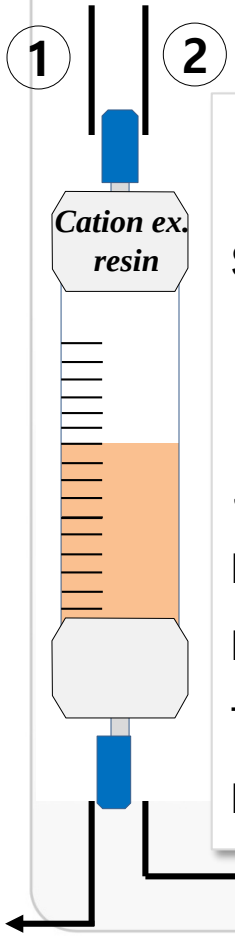
Cation ex. resin (4 ml, BV)
Conditioning: DIW 5 BV (de-ionized water)
Loading : seawater 100 ml (filtered)

Cation ex. resin + Sr resin (2 ml, BV)
Washing 1 : 8M HNO_3 9 BV

Only Sr resin (2ml, BV)
Washing 2 : 8M HNO_3 4 BV
Elution : DIW 5 BV

^{90}Sr in seawater

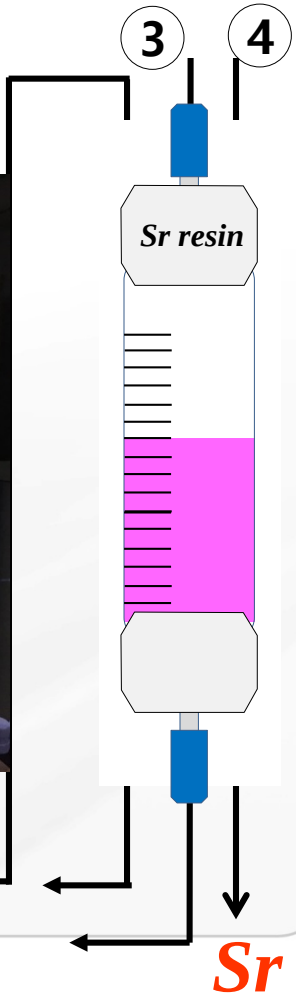
Normal | **Emergency**



Result

Seawater 100 ml (n=8)

Cation ex. resin	4 ml (BV)
Sr resin	2 ml (BV)
Recovery Sr	71 – 78 %
Relative error	-3 ~ 5 %
Time	25 min
Flow rate	7 ml/min



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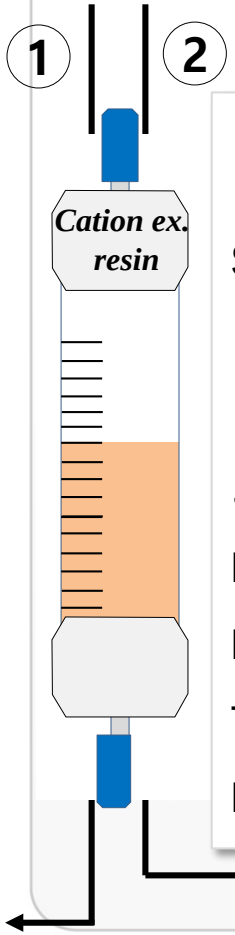
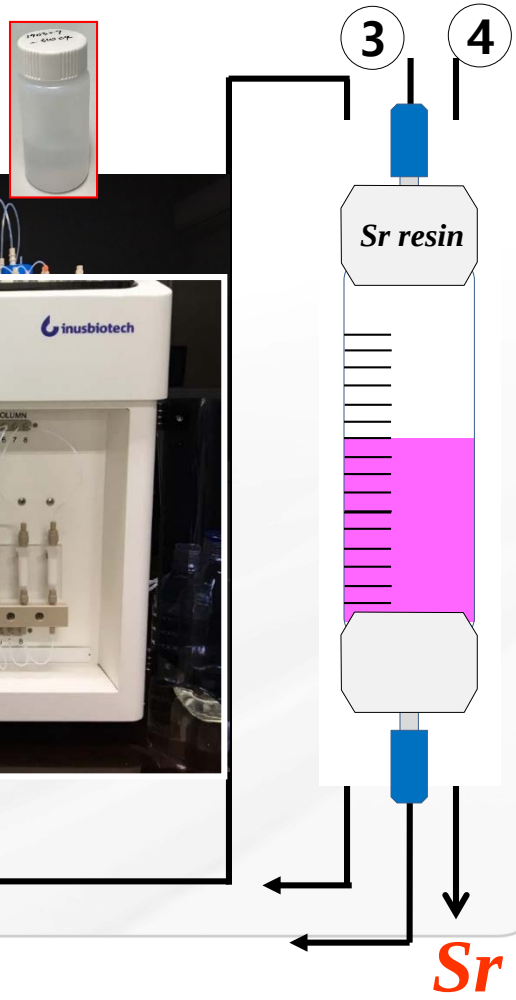


Result

Seawater 100 ml (n=8)

Cation ex. resin	4 ml (BV)
Sr resin	2 ml (BV)
Recovery Sr	71 – 78 %
Relative error	-3 ~ 5 %
Time	30 min
Flow rate	7 ml/min



Conclusion

◆ Analytical method for radiostrontium ($^{90}Sr/^{89}Sr$) in seawater

◆ Routine monitoring: *DGA resin* + *TRU resin*

For 10 L of seawater, we have 80 % of recovery (Y), 5 % of relative error, and finished the separation within 3 h (25 ml min^{-1}).

◆ Emergency preparedness: *cation ex. resin* + *Sr resin*

For 0.1 L of seawater, we have 73-78 % of recovery (Sr),

-3 to 5 % of relative error, and finished the whole separation within 30 m.