Rapid Determination of Sr in 1-2 Liter Seawater Samples

**Summary of Method**  Strontium is separated and concentrated from 1-2L samples of seawater with a calcium phosphate precipitation, enhanced with 200mg of iron. Strontium is separated from matrix impurities and potentially interfering radionuclides in the sample using two stacked 2mL cartridges of Eichrom Sr Resin. Radiostrontium is measured on a low background gas flow proportional counter or liquid scintillation counter. Chemical yield of strontium is determined by gravimetric recovery of native stable strontium in the seawater or by ICP-AES measurement. Average chemical recovery of strontium is 89 ± 5% for 1L samples and 82 ± 4% for 2L samples. Measured values of 90Sr agreed to within 1% and 4% of reference values, for 1L and 2L, respectively, with two hour count times. The minimum detectable activity for 90Sr for 2L samples with a two hour count time is 9.1Bq/L. A single operator can prepare batches of 12-24 samples for measurement of radiostrontium in less than 8 hours.

**Reagents**
- Sr Resin, 2mL Cartridges (Eichrom SR-R50-S)
- Nitric Acid (70%)
- Ammonium Hydroxide (listed as 28% NH₃ or 56% NH₄OH)
- Deionized Water
- Iron Carrier (50mg/mL Fe, as ferric nitrate)
- 3.2M (NH₄)₂HPO₄
- 2M Al(NO₃)₃
- 90Sr standard
- Oxalic acid

**Equipment**
- Vacuum Box (Eichrom AR-24-BOX or AR-12-BOX)
- Cartridge Reservoir, 20mL (Eichrom AR-200-RV20)
- Inner Support Tubes-PE (Eichrom AR-1000-TUBE-PE)
- Yellow Outer Tips (Eichrom AR-1000-OT)
- 50mL Centrifuge Tubes
- 250-500mL Centrifuge Tubes
- Centrifuge
- Cupped Stainless Steel Planchets (~5mL volume)
- Gas Flow Proportional Counter
- Hot Plate
- Analytical Balance
- Vacuum Pump

**Figure 1. Sample Preparation**

1-2L Sample of Seawater.
Add 200mg Fe(III), and 25mL 3.2M (NH₄)₂HPO₄.
Mix Well.
Adjust to pH 10 with ~30mL of 56% NH₄OH while stirring.
Centrifuge for 10 minutes in 250 or 500mL tubes at 3000rpm, decanting supernate to waste, until entire sample has been processed.
Wash precipitate with 50mL of pH 9 NH₄OH.
Centrifuge for 10 minutes at 3000rpm.
Decant supernate to waste.
Dissolve precipitate in 25mL 70% HNO₃.
Transfer to 50mL centrifuge tube.
Rinse centrifuge tube with 8mL 2M Al(NO₃)₃ and 5mL 3M HNO₃.
Transfer tube rinse to Sr samples in 50mL centrifuge tube.
Load Solution to Sr Resin Separation.
Figure 2. Strontium Resin Separation (Optional 90Y Ingrowth)

(1) Precondition Sr Resin with 10mL 8M HNO₃.
(2) Load sample at 1-2mL/min.
(3) Rinse sample tube with 5mL 8M HNO₃.
(4) Add tube rinse to Sr Resin. Elute at 1-2mL/min.
(5) Rinse Sr Resin sequentially with:
   - 15 mL 8M HNO₃
   - 10mL 3M HNO₃ - 0.05 oxalic acid
   - 10mL 8M HNO₃
(6) Dispose of (1) to (5) as waste.
(7) Strip Sr with 20mL 0.05M HNO₃ at 1mL/min.
(8) Evaporate samples to dryness on tared cupped stainless steel planchets.
(9) Rinse Sr sample vials with 2mL 0.05M HNO₃. Transfer vial rinse to planchets. Evaporate to dryness.
(10) Weigh planchets on an analytical balance to determine gravimetric yield of stable Sr(NO₃)₂.
(11) Measure radiostrontium in samples on low background gas flow proportional counter.

*(Options for 89/90Sr Discrimination)
(a) Sr fraction from step (7) can be transferred to a liquid scintillation vial. ⁸⁹Sr can be measured by Cerenkov counting (no LSC cocktail). ⁸⁹/⁹⁰Sr can then be measured by adding liquid scintillation cocktail.
(b) Sr fraction from step (10) can be dissolved in 10mL 8M HNO₃ after >7 days of ⁹⁰Y ingrowth. ⁸⁹/⁹⁰Sr can be removed on Sr Resin. ⁹⁰Y will elute in Sr Resin load and can be counted by liquid scintillation or gas flow proportional counting.

Performance of ⁹⁰Sr Method for 1L and 2L Seawater Samples

<table>
<thead>
<tr>
<th>Sample Replicates</th>
<th>Sample Volume, L</th>
<th>⁹⁰Sr, Reference Value (mBq/L)</th>
<th>⁹⁰Sr, Measured Value (mBq/L)</th>
<th>% Bias</th>
<th>Sr carrier % Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>1</td>
<td>148</td>
<td>150 ± 11</td>
<td>1.2</td>
<td>89 ± 5</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>148</td>
<td>154 ± 5</td>
<td>4.2</td>
<td>82 ± 4</td>
</tr>
</tbody>
</table>

2 hour count times
MDA = 9.1 mBq/L for 2L sample

References