Elevated Radioactivity in Groundwater in Charles County, Maryland

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STUDY AREA
BACKGROUND

- 1998: Gross alpha-particle activity (GAPA) >15 pCi/L in Chapel Point Woods water system, Charles County, Maryland
- Four other water systems exceeded 15 pCi/L GAPA
- Radium-226 + radium-228 were below 5 pCi/L
- Polonium-210 detected in two systems (maximum: 46 pCi/L)

QUESTIONS

- Is radioactivity restricted to a particular stratigraphic interval(s)?
- Are private water wells at risk?
- Why here?
STUDY OBJECTIVES

1) Compile and document existing data on radioactivity in groundwater in Charles County, Maryland (Maryland Department of the Environment PDWIS database)

2) Determine if radioactivity is restricted to specific zones

3) Identify nearby wells that may be at risk for elevated radioactivity (particularly residential wells)
URANIUM-238 DECAY SERIES

U-238 4.5x10^4 y

Th-234 1.2 m

Th-234 24.1 d

Ra-226 1.622 y

Rn-222 3.8 d

Po-218 3.1 m

Po-214 1.6x10^7 s

Bi-214 19.7 m

Pb-214 26.8 m

Pb-210 22.3 y

Pb-206 stable

Pb-210 5.0 d

U-234 2.5x10^5 y

Th-230 7.5x10^3 y

Ac-228 6.13 h

Th-228 1.90 y

Ra-224 3.64 d

Rn-220 55 s

Po-216 0.16 s

Bi-212 60.5 m

Pb-210 138.4 d

Po-210 10.6 h

Bi-212 60.5 m

Pb-212 stable

Th-228 5.75 y

EXPLANATION

↓ Alpha decay

↑ Beta decay

% percent

THORIUM-232 DECAY SERIES

Modified from Aieta and others (1987)
Generalized Cross Section Through the Maryland Coastal Plain

Not to scale
Objective #1: Compile and document existing data

78 public water systems (PWS) tested:

- 58 community (municipal supply)
- 20 non-community (mostly schools)

Data Source: Maryland Department of the Environment
78 systems tested:

- 5 systems >15 pCi/L
- 11 systems between 10-15 pCi/L
- 62 systems <10 pCi/L (most <3 pCi/L)
Radionuclide Concentrations (78 PWS)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Range (pCi/L)</th>
<th>Mean (pCi/L)</th>
<th>Maximum Contaminant Level (pCi/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Alpha</td>
<td>0.2 - 122</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Gross Beta</td>
<td>0.15 - 47</td>
<td>6.2</td>
<td>~50 pCi/L (4 mrem/yr)</td>
</tr>
<tr>
<td>Radium 226+228</td>
<td>0.1 – 4.6</td>
<td>1.1</td>
<td>5</td>
</tr>
<tr>
<td>Radium-224</td>
<td>Not tested but likely low</td>
<td></td>
<td>No MCL</td>
</tr>
<tr>
<td>Uranium</td>
<td>0.06 - 9.4 ug/L</td>
<td>1.9 ug/L</td>
<td>30ug/L</td>
</tr>
<tr>
<td><strong>Po-210</strong></td>
<td><strong>2.8 – 46.6</strong></td>
<td><strong>23.1</strong></td>
<td>No MCL</td>
</tr>
</tbody>
</table>

NIST Po-210 Study: Outola, et. al, 2008
Polonium-210 in groundwater

- **Very rare**
  - Not often tested
  - Less than 100 wells nationwide reported levels greater than 5 pCi/L (Nevada, Virginia, Florida)
  - Highest in Charles County was 46.6 pCi/L

- **No MCL for Po-210**

- **“Activity level of concern” of 1.1 pCi/L**
  (equivalent to risk level of combined radium at 5 pCi/L MCL) [U.S. EPA, 1999]

- **Occurrence/distribution**
  - Considerable data/knowledge gap
  - Mobilized in anoxic sulfate-reducing environments(?)
Objective #2: Are specific parts of the aquifer affected?

Water samples are a composite from multiple well screens spanning 900 feet of sediment.
Upper, Lower Patapsco Aquifer (Potomac Group):

- Fluvio-deltaic system
- Southwest of main axis of deposition
  (higher clay/silt fraction)

Sands:
- Gray, greenish-gray; some yellow/reddish brown
- Predominantly subangular to subrounded quartz
  (mostly colorless; some iron coatings)
- Accessory minerals: pyrite, lignite, muscovite

Clays:
- Highly variable color, texture
- Mostly medium-dark silty gray clays
Objective #3: Are private water wells at risk?

Process
Wells were identified that are completed in the U&L Patapsco aquifers within a 1-mile radius (location accuracy issues?)

Results
Total of 113 wells
93 residential
14 PWS (non-community)
6 irrigation/farm
Summary

• Radioactivity above MCL’s is limited (5 PWS’s out of 58 total)
• Po-210 is the likely source (at 2 PWS’s and possibly more)
• Can’t determine distribution within the aquifers (composite samples from multiple well screens)
• Significant number of wells likely screened at the same intervals located nearby (mostly residential)

What’s Next?

• Sample ~90 public water-supply wells having GAPA 5-15 pCi/L (GAPA, GBPA, radium, Po-210, uranium)
• Sample ~30 private water wells near PWS wells with high GAPA (test for GAPA, GBPA only)
• After that…..???
Report available online at Maryland Geological Survey website: www.mgs.md.gov

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