POLONIUM-210 AND DRINKING WATER: OCCURRENCE IN MINNESOTA AND HEALTH RISK IMPLICATIONS

James Jacobus, Ph.D.
Minnesota Department of Health

October 26, 2015

Special Note

- MDH has not developed a specific policy or interpretation of the exposures and risks to date

- Po-210 occurrence in groundwater is an ongoing project under the Minnesota Department of Health's Contaminants of Emerging Concern program

Acknowledgements

MN Department of Health:

- James Lundy, Source Water Protection
- Anna Schliep, Drinking Water Protection
- Karla Peterson, Drinking Water Protection
- Jeff Brenner and Jessie Fillmore, MDH Public Health Laboratory

Po-210 and Pb-210 Analysis:

- Pace Analytical, Inc.

Wonderful colleagues:

- Mike Schultz, University of Iowa
- Lowell Ralston, USEPA
- Paul Stackelberg, USGS

Funding Provided by:

CLEAN WATER LAND & LEGACY AMENDMENT

MINNESOTA MDH DEPARTMENT OF HEALTH

Focus

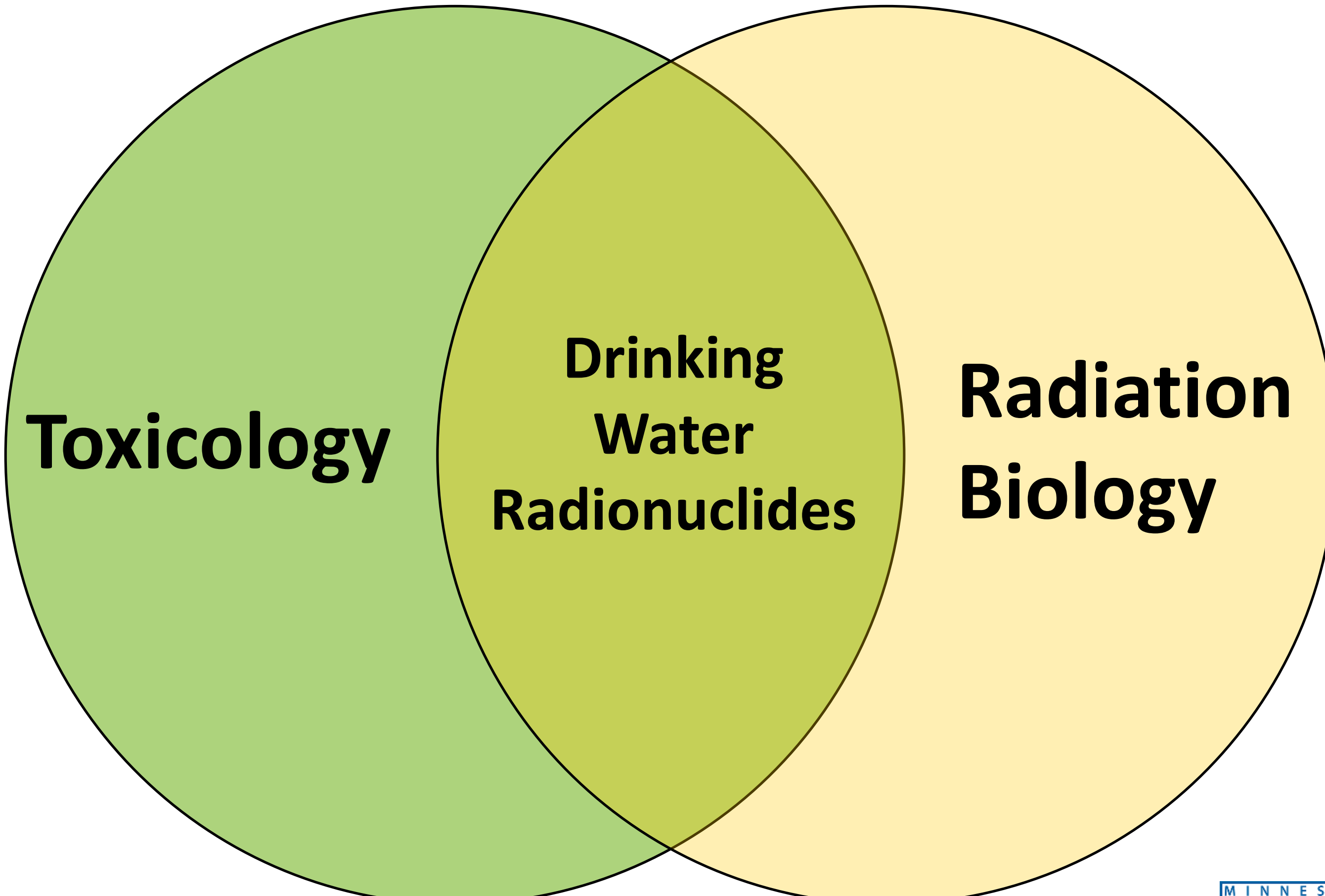
- Polonium-210 (Po-210) and other Naturally-occurring radionuclides (NORM) in MN drinking water sources

- Cancer is the major health risk, low level exposures

- Groundwater used for drinking water

- Minnesota and northern Midwestern states are known for elevated radionuclides in soil and groundwater

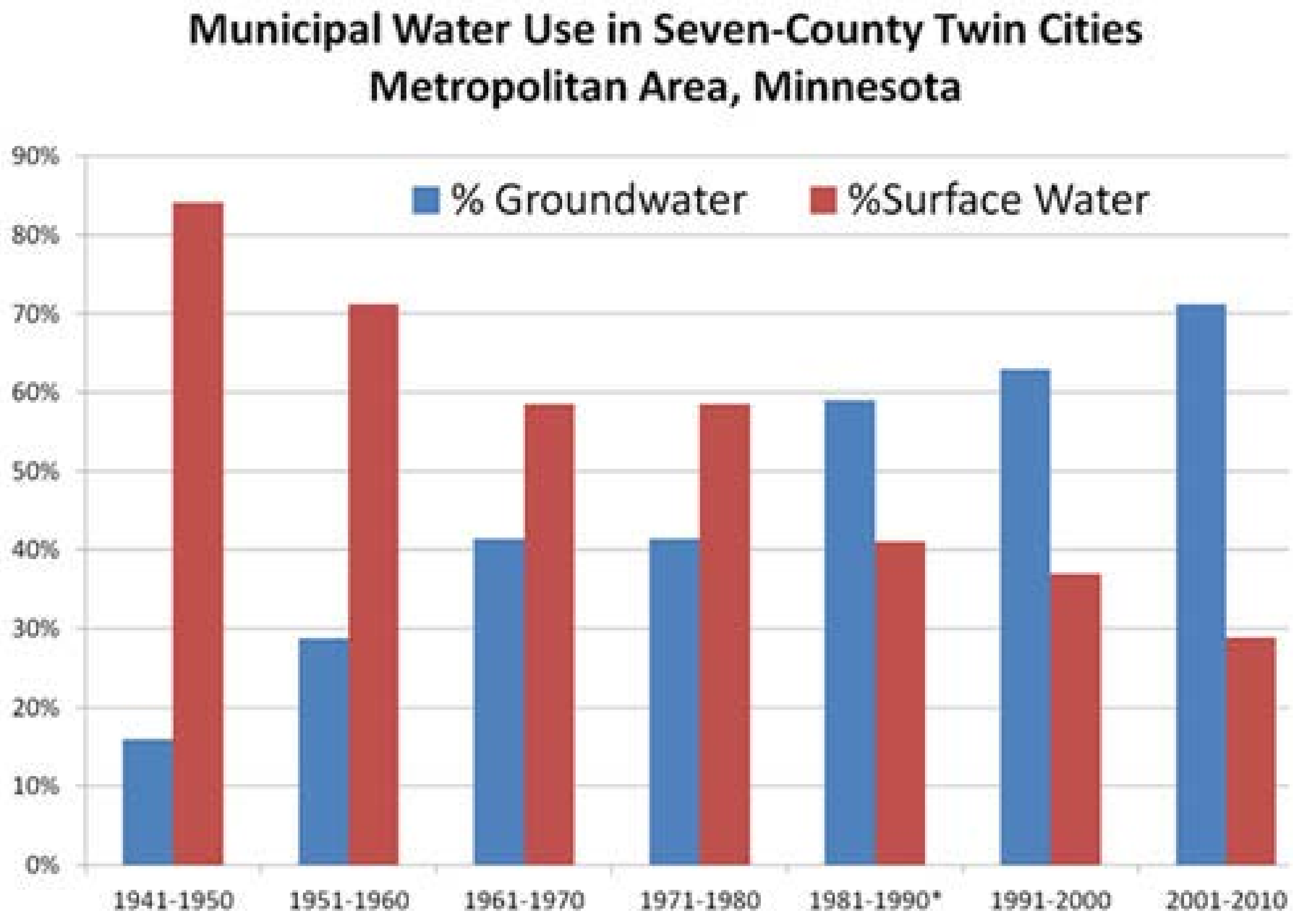
Assessment of radionuclides in drinking water requires fundamentals of chemical toxicology and radiation biology.



Background Exposure

- Average annual exposure range is 300-600 mrem / 3-6 mSv
- Medical diagnostics such as CT/x-rays and radiation therapy can greatly increase an individual's annual radiation exposure
  - Fastest growing source of radiation exposure at the population level in the US
- Increasing use of groundwater resources can also be a source of increasing exposure to environmental radiation sources

Groundwater Use Increasing



Metro Council, Minnesota

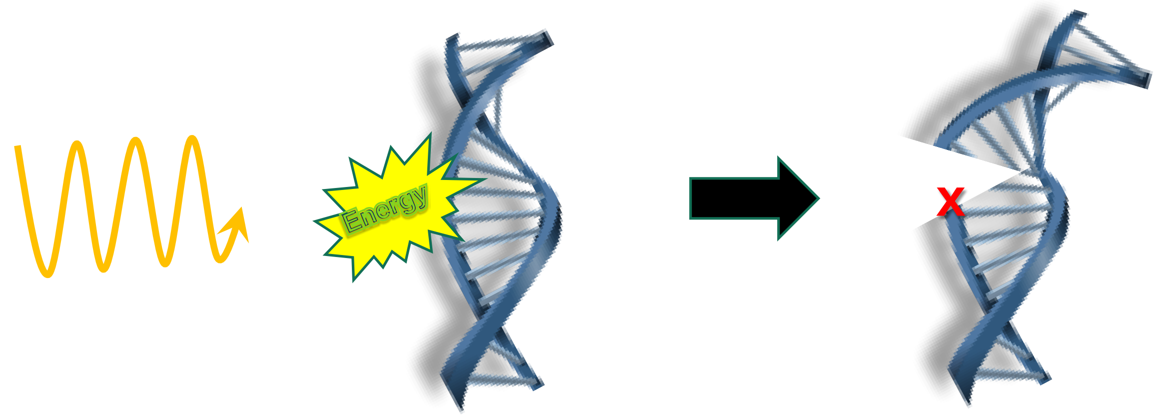
Cumulative Counts

- Small doses of radiation (mSv), over the course of a lifetime, cumulatively increase risk of cancer
- Those with longer to live (children) encumber greater risk from equivalent dose exposure compared to adults
- Therefore, limiting exposure where possible is important for public health
- Limiting most potent exposures even more critical (α)

MINNESOTA MDH DEPARTMENT OF HEALTH
CLEAN WATER LAND & LEGACY AMENDMENT

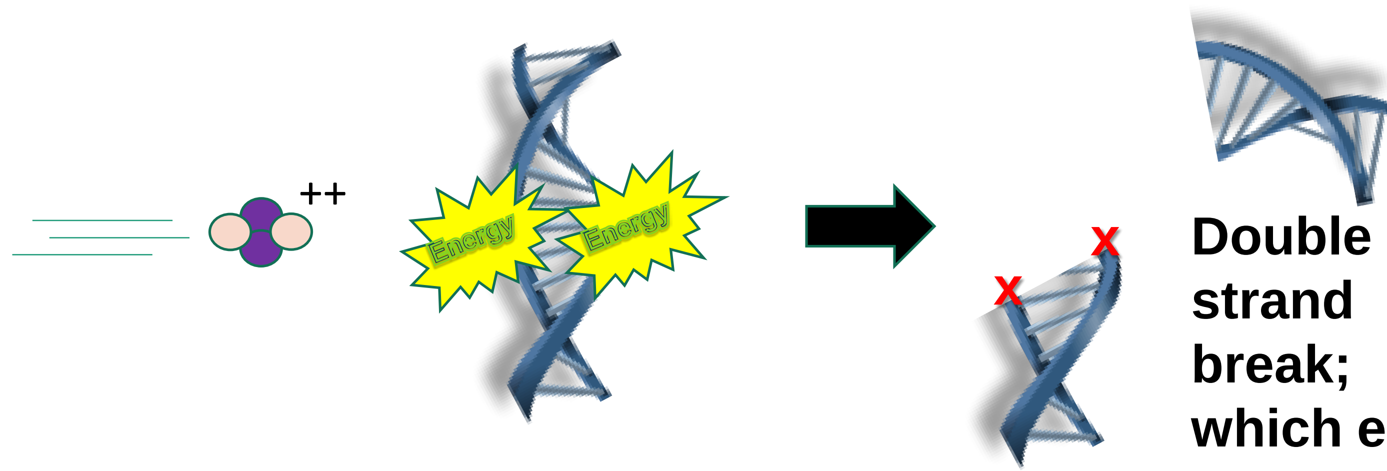
Mechanism of Toxicity: Breaking DNA

Sparsely Ionizing (wave)



Single strand break; easy fix

Densely Ionizing (particle)



Double strand break; which end is up??

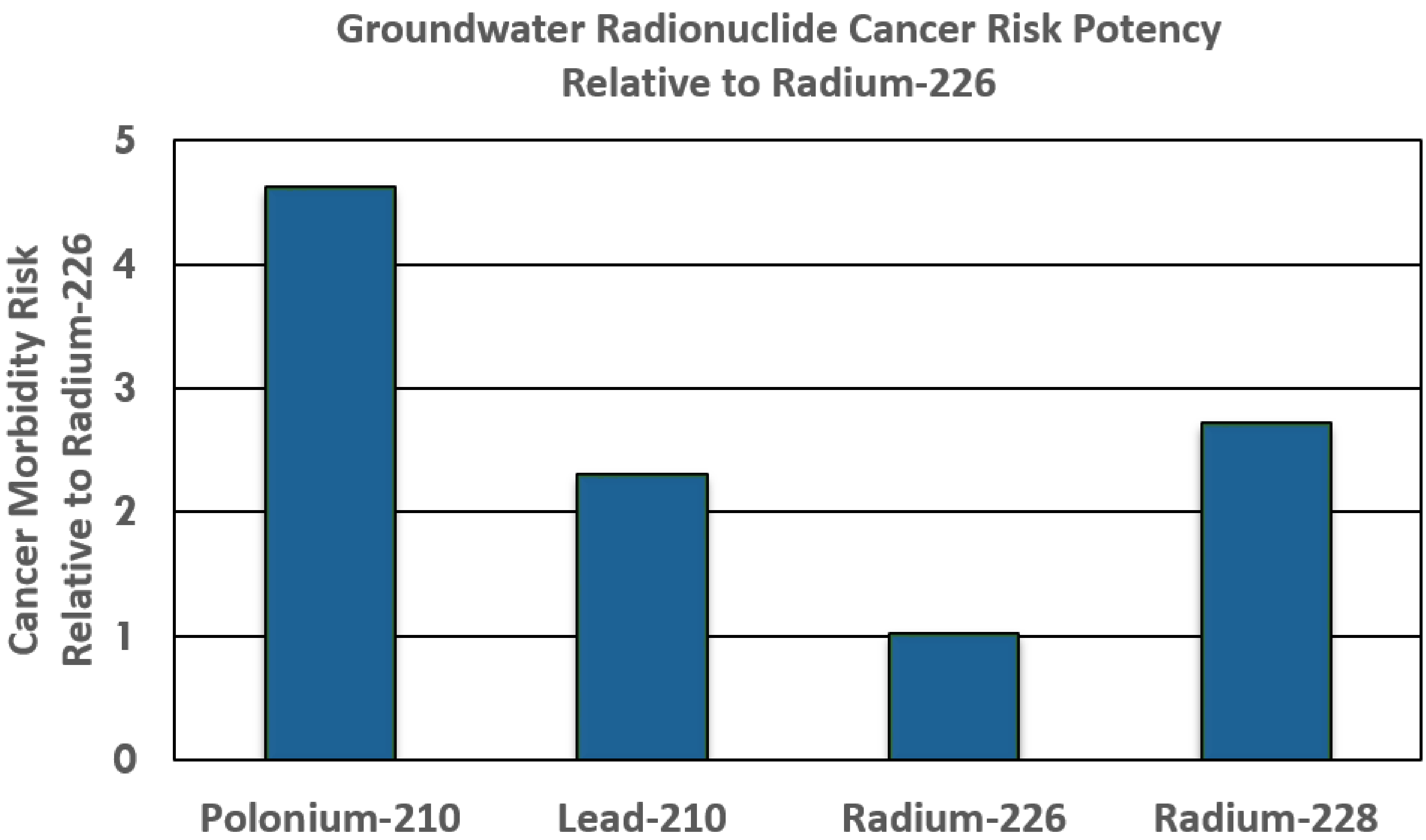
Why Focus on Po-210?

- Potent alpha emitter and known human carcinogen
  - Biological half-life of ~50 days
  - Readily taken up by GI tract, especially in children
  - Partitions to organs and tissues, rather than bone
- Scant data on Po-210 in drinking or ground water
- Radium-226, ‘parent’ of Po-210, elevated in Minnesota
- Gross alpha elevations could be due to Po-210 levels
- EPA has expressed concern over Po-210, but no new comprehensive study completed since addition to UCMR in 2000

MINNESOTA MDH DEPARTMENT OF HEALTH

CLEAN WATER LAND & LEGACY AMENDMENT

Relative Potency of Selected Radionuclides



Pilot Study Design, Po-210 and Pb-210

- Select sampling sites based on hierarchy of gross alpha levels known from compliance monitoring

- 32 source water samples spread across various aquifers
  - 4 entry point (post-treatment) samples
  - Split sampling at five sites with USGS to examine interlab var.

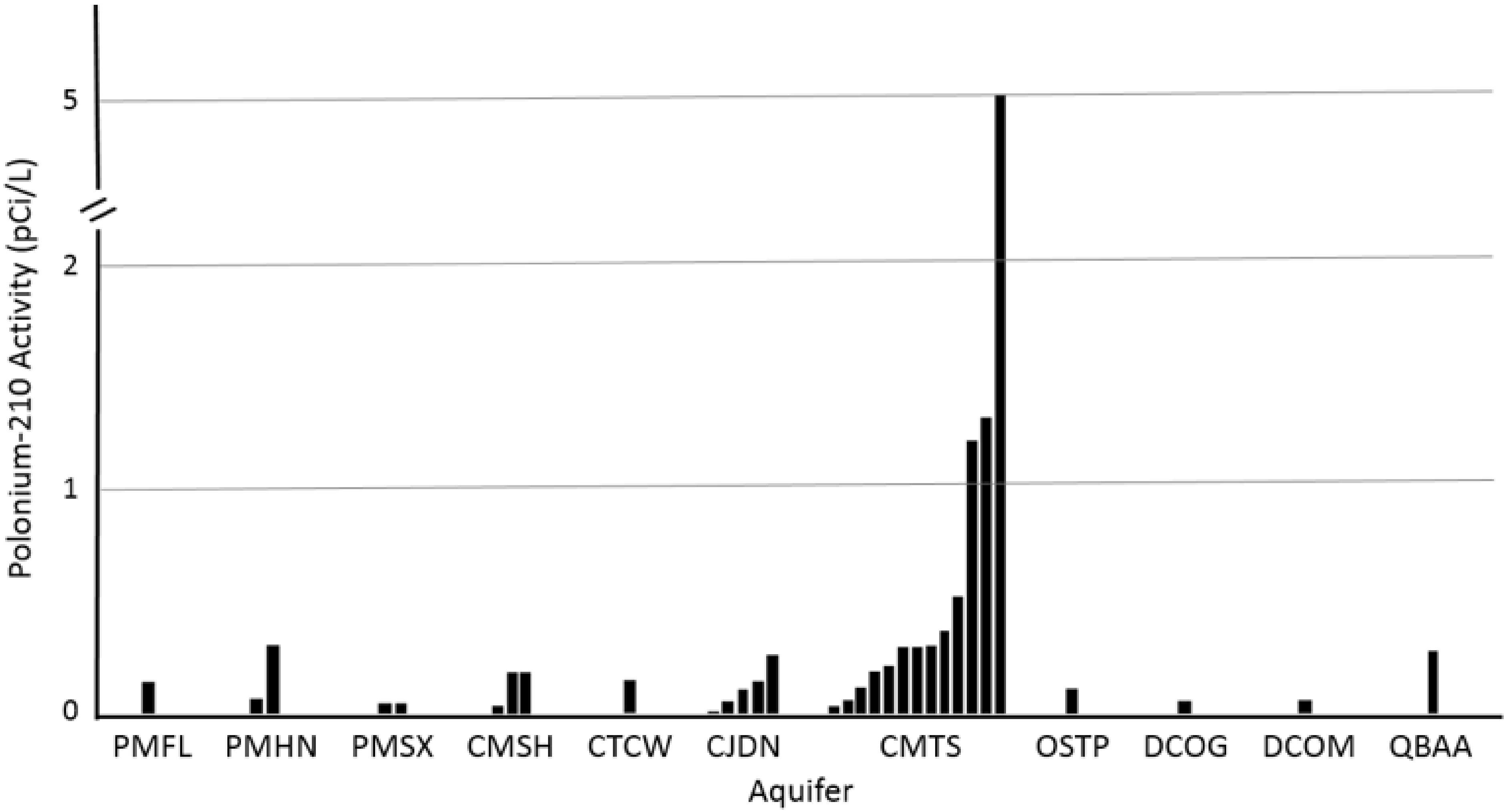
- Paired gross alpha time course analysis with Po-210

- 10 samples were also analyzed for lead-210

Minnesota Well Code

- Wells in Minnesota cannot be open to more than one aquifer
- All wells in this study draw water from a single aquifer
- Wells in other states are often open to all aquifers readily accessible in the boring, mixing water types

Po-210, By Aquifer



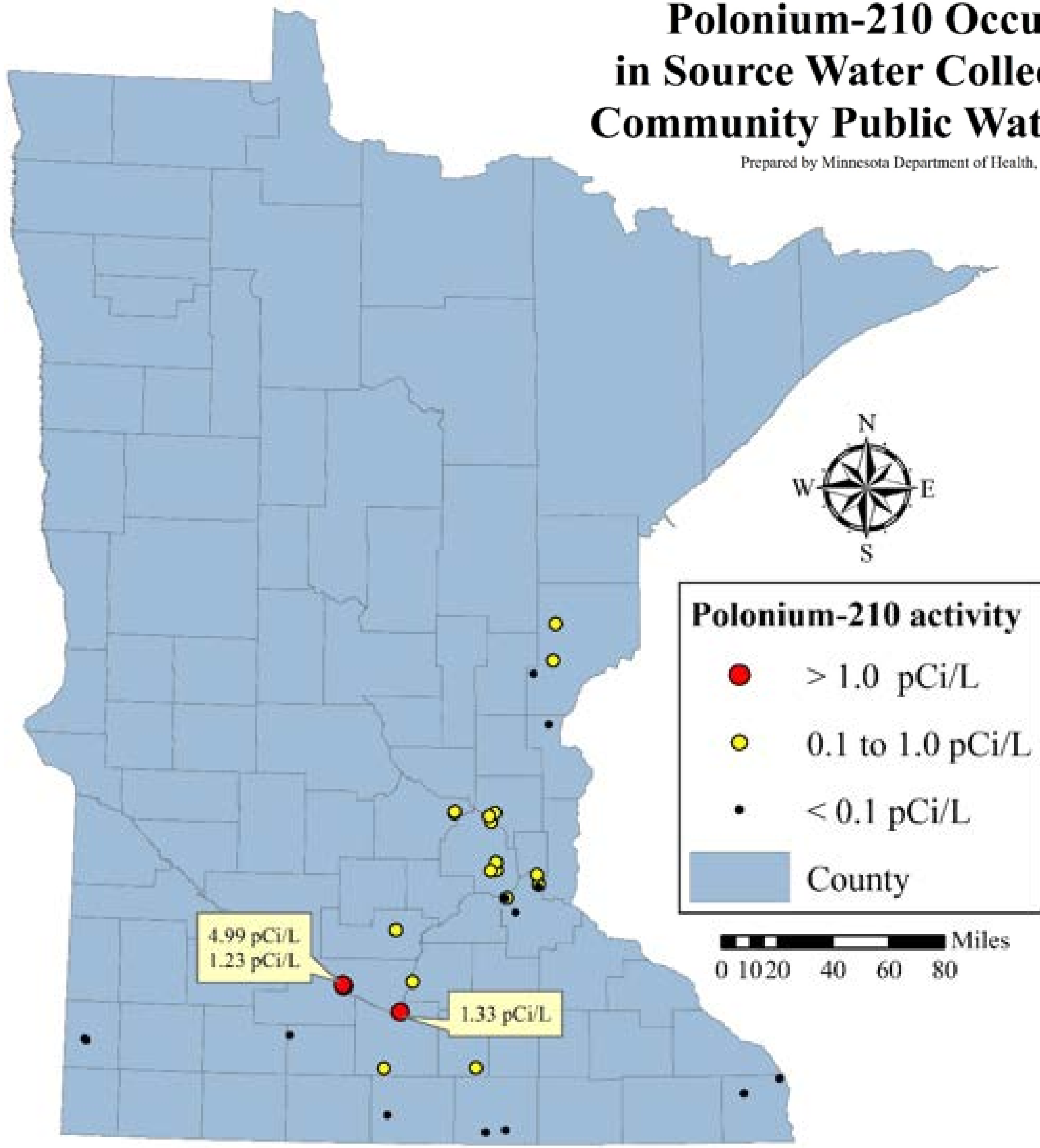
Aquifer acronyms: CTCW (Tunnel City-Wonewoc), CJDN (Jordan), CMSH (Mt. Simon-Hinckley), CMTS (Mt. Simon), DCOG (Cedar Valley-Galena), DCOM (Cedar Valley-Maquoketa), PMFL (Fond du Lac Formation), PMHN (Mt. Simon-Hinckley), PMSX (Sioux Quartzite), OSTP (St. Peter), QBAA (Quaternary buried artesian aquifer)

Po-210 and Pb-210 Results

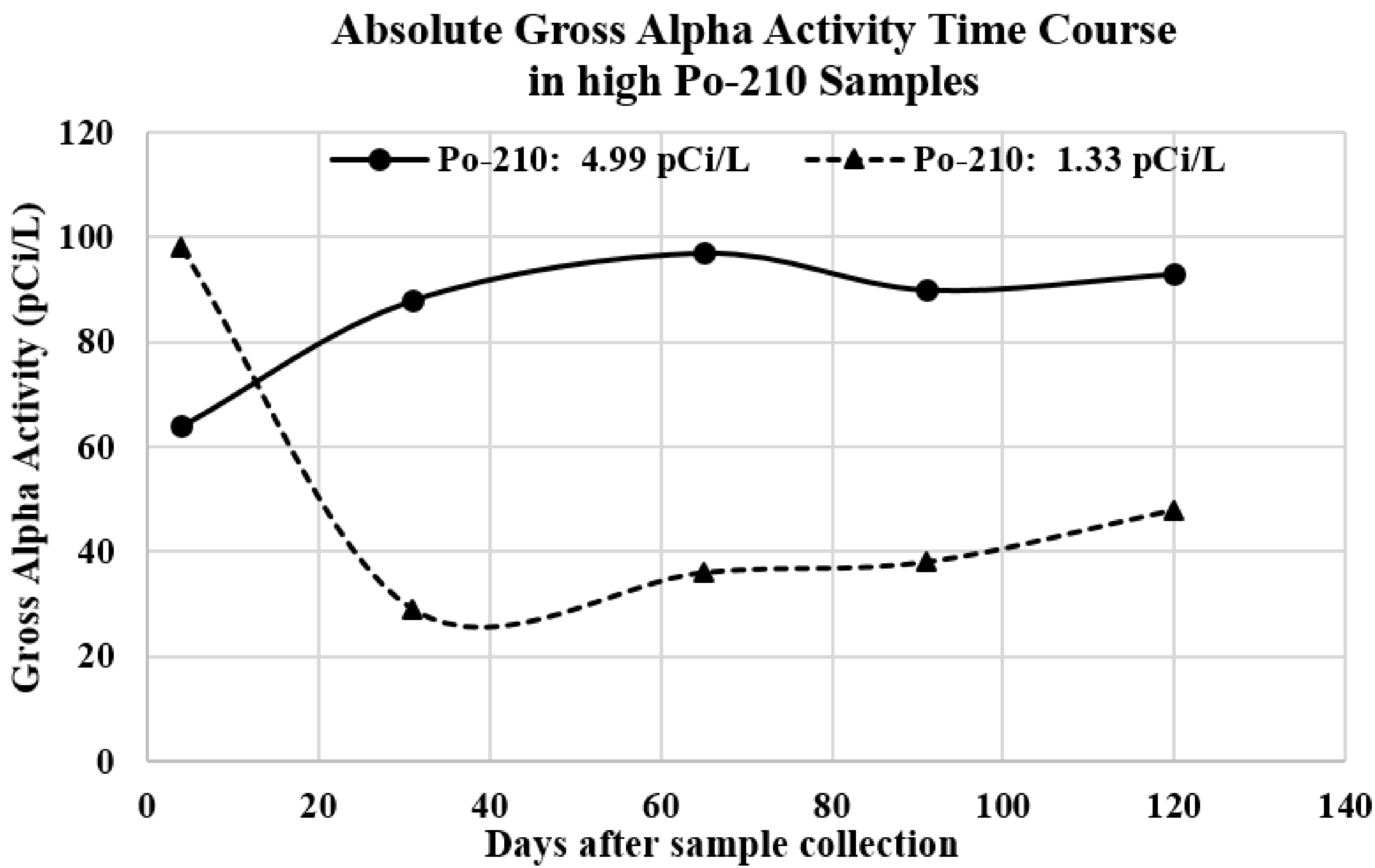
Well #	Po-210 (pCi/L)	Pb-210 (pCi/L)
430604	4.99 (±0.75)	0.551 (±0.31)
415943	1.33 (±0.09)	0.326 (±0.18)
241335	1.23 (±0.21)	0.702 (±0.32)
151559	0.528 (±0.13)	--
645355	0.371 (±0.09)	0.631 (±0.26)
Entry Point #3	0.334 (±0.09)	2.870 (±0.41)
206456	0.308 (±0.09)	0.120 (±0.17)
Entry Point #1	0.232 (± 0.08)	1.52 (± 0.28)

Polonium-210 Occurrence in Source Water Collected from Community Public Water Supplies

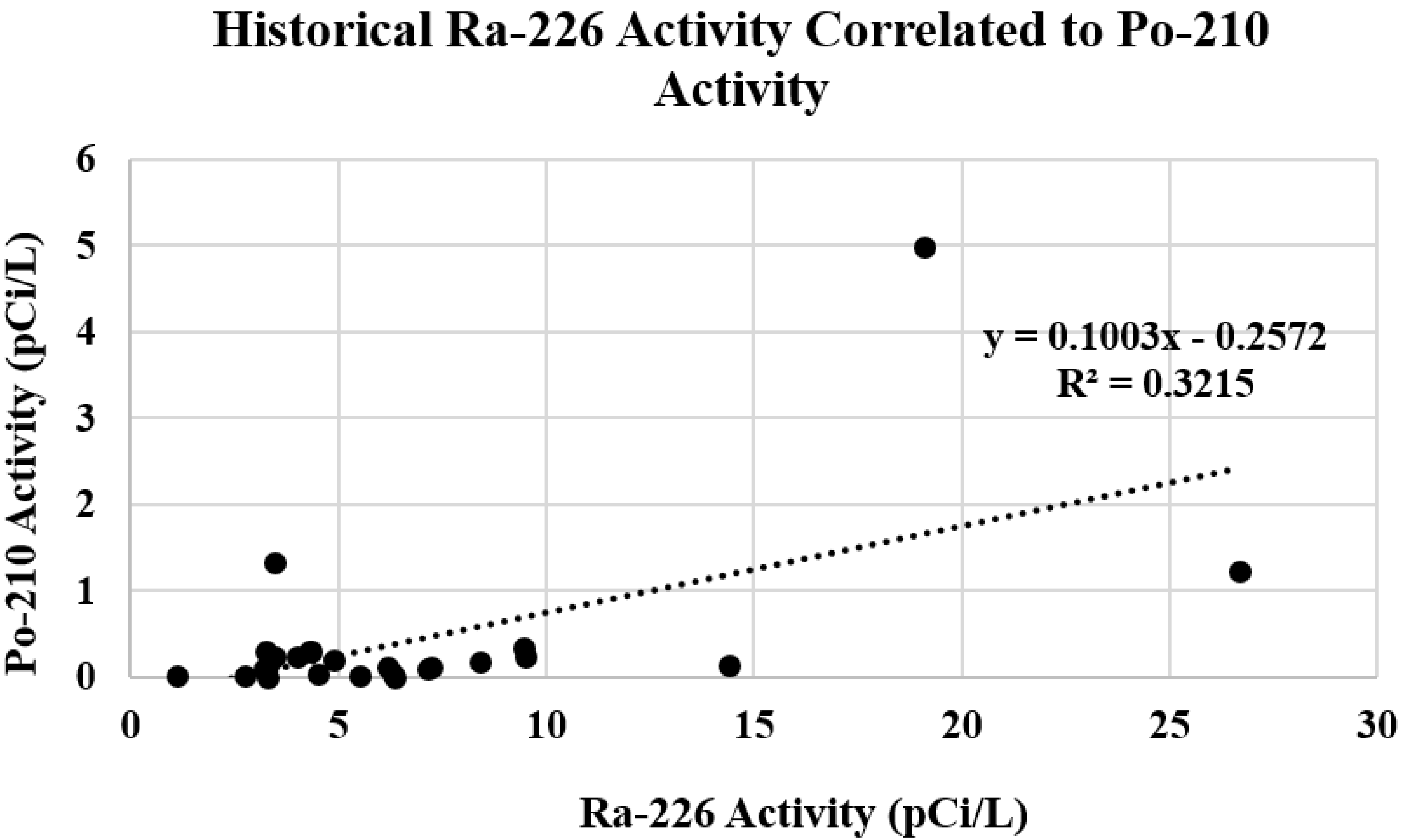
Prepared by Minnesota Department of Health, July 2015



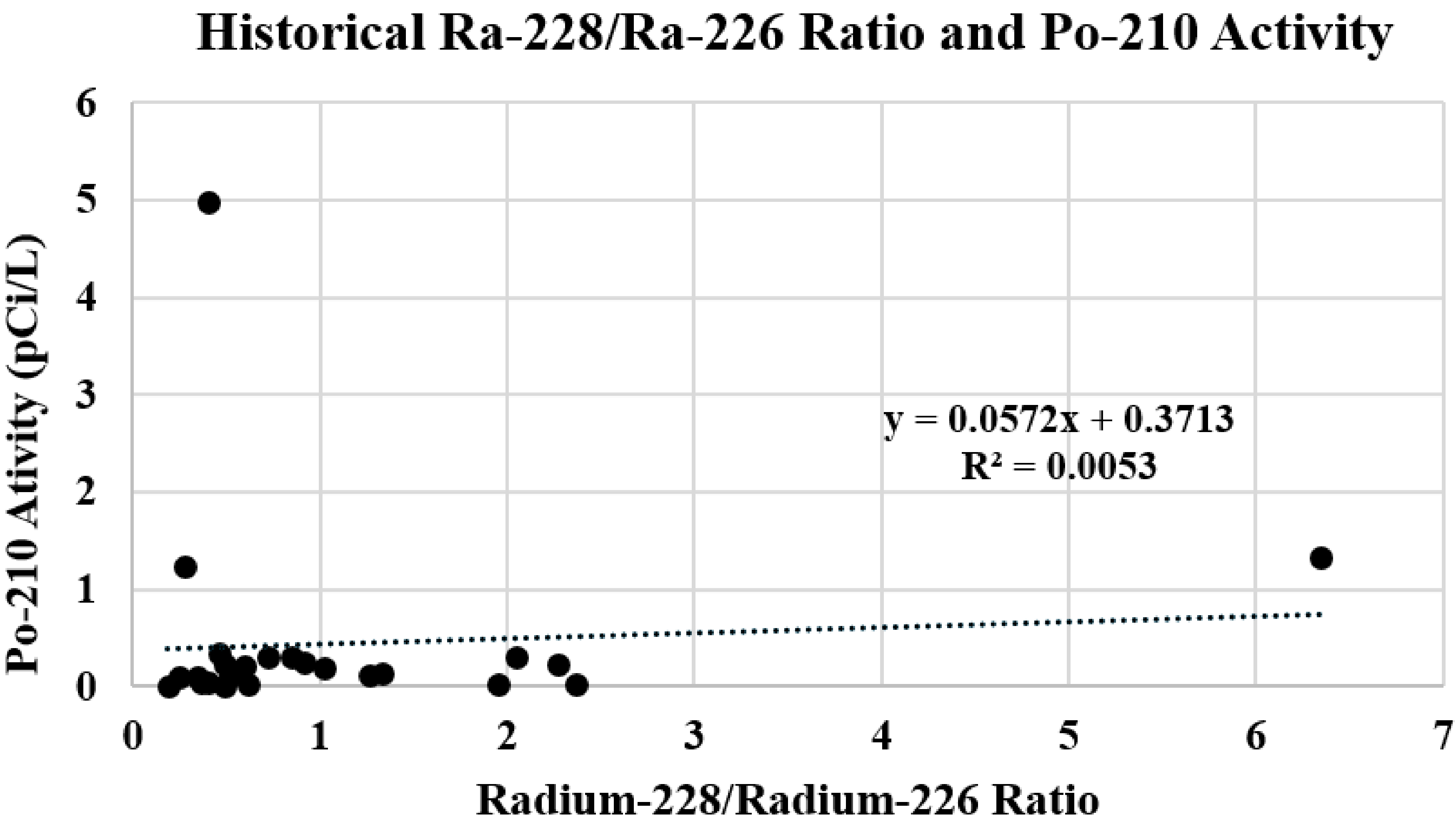
Gross Alpha trends over time



Correlation with Radium-226 (Historical data)



Ra-226/Ra-228 ratio and Po-210



Major Findings

- Po-210 is found at low levels in many aquifers, with highest levels found in Mt. Simon
- Highest levels found in relatively shallow Mt. Simon wells
- Two post-treatment samples contained highest activity of Pb-210
- Po-210 was found in three source wells above 1 pCi/L, with a maximum detection of 5 pCi/L

Po-210 Health Risk Assessment

- Po-210 radiation doses, delivered over a lifetime, may be contributing extra cancer morbidity risk between 1:100,000 (within the acceptable risk range) and 1:2,000 (outside of range)
- Gross alpha screening level of 15 pCi/L not low enough to account for Po-210 health risks
- Cumulative nature of radiation exposures throughout life warrants identification and reduction of Po-210 exposure in possible drinking water sources

Future Steps

- As neither gross alpha nor radium were good predictors of Po-210 in groundwater, continued monitoring efforts are needed to understand risks and exposures in Minnesota

- Does current treatment reduce Po-210?

- Is radon supporting Pb-210 in treatment plant effluent?

- Can domestic wells contain Po-210 >1 pCi/L?

Questions and Discussion

Acknowledgements

MN Department of Health:

- James Lundy, Source Water Protection
- Anna Schliep, Drinking Water Protection
- Karla Peterson, Drinking Water Protection
- Jeff Brenner and Jessie Fillmore,
  MDH Public Health Laboratory

Po-210 and Pb-210 Analysis:

- Pace Analytical, Inc.

Wonderful colleagues:

- Mike Schultz, University of Iowa
- Lowell Ralston, USEPA
- Paul Stackelberg, USGS

Funding Provided by:

CLEAN WATER LAND & LEGACY AMENDMENT

MINNESOTA MDH DEPARTMENT OF HEALTH