THE DANGERS FROM THE RADIOACTIVITY OF PRODUCED WATER

NORM is the acronym used for naturally occurring radioactive materials that are present in many, if not all, liquid wastes from hydraulic fracturing, referred to as "produced water". These liquid wastes are commonly stored before reprocessing or in some cases left in open pools. Being "naturally occurring" one might think of them as relatively harmless sources of radioactivity. Papers in the July 2015 issue of Environmental Health Perspectives suggest otherwise, particularly for the produced water stored in closed containers.

A summary appears in http://ehp.niehs.nih.gov/123-A186
The main source paper is by A.W. Nelson et al, Environmental Health Perspectives, Vol. 123, No.7, July 2015:
http://dx.doi.org/10.1289/ehp.1408855
These authors carried out a careful analysis of the growth of radioactivity in closed containers of produced water from Marcellus Shale. This included contributions from uranium, thorium, actinium, radium, lead, bismuth and polonium isotopes, measured quantitatively using high-purity germanium gamma spectrometry
https://en.wikipedia.org/wiki/Gamma_spectroscopy
and isotope dilution alpha spectrometry.
https://en.wikipedia.org/wiki/Isotope_dilution The results were compared with theoretical calculations of the radioactivity to be anticipated from the stepwise decay of the parent Uranium 238 or Thorium 232, the most abundant long-lived naturally occurring radioactive isotopes.

For example, decay of ^{238}U, with a half-life of 4.5 billion years, occurs through short half-lived ^{234}Th (24.1 day) and ^{234}Pa (1.17 min) to ^{234}U, which has a half-life of 245.5 thousand years, and on to ^{230}Th, with a half-life of 75.4 thousand years, finally reaching ^{226}Ra having a half-life of 1602 years. Next in this series is ^{222}Rn, radon, a gas with a half-life of only 3.82 days. If this material is retained and not allowed to escape, products from its decay are ^{218}Po (3.1 min), ^{214}Pb (26.8 min), ^{214}Bi (19.9 min), ^{214}Po (1.64 $X10^{-4}$ s), ^{210}Tl (1.3 min), ^{210}Pb (23.2 yr.), ^{210}Bi (5.01 day) and ^{210}Po (138 day), finally reaching stable ^{206}Pb.

Decay of ^{232}Th is even slower, with a half-life of 14.05 billion years, producing first ^{228}Ra, with 5.75 year half-life, next ^{228}Ac (6.25 h), then ^{228}Th of half-life 1.9 years, ^{224}Ra (3.63 days), ^{220}Rn (55.6 sec). This is another isotope of radon, a gas that might escape if not confined. Daughter products of ^{220}Rn are all short lived, consisting of ^{216}Po

(0.145 s), ^{212}Pb (10.6 h), ^{212}Bi (60.5 min), ^{212}Po (299 ns) and ^{208}Tl (3.05 min) leading to stable ^{208}Pb.

In produced water from the Marcellus Shale, previously only radioactivity attributable to radium has been reported, the naturally occurring isotopes ^{226}Ra and ^{228}Ra being present at more than 670 Bq/L and 95 Bq/L, respectively. {1 Bq is 1 disintegration per second} These were the same as the gross alpha activity in the new Nelson et al paper; evidently radioactive daughters of radium were not extracted into the fluid but left behind in the solid phase.

The new work looked also at environmentally persistent alpha- and beta-emitting NORM. It found, using isotope dilution alpha spectrometry, that for produced water stored sealed for periods up to nearly a year that the activity of ^{210}Po increased 27-fold, comparing 21 days of storage to 278 days, the activity at the end being 4 Bq/L; the activity of ^{228}Th rose from 5.75 Bq/L after 66 days to 22 Bq/L at 278 days. Initially, the radioactive concentrations of both these and other Ra decay products: ^{214}Pb, ^{214}Bi, ^{212}Pb, ^{210}Pb, ^{208}Tl had been near methodological detection limits, while the natural U (^{238}U, ^{235}U, ^{234}U) and Th isotopes (^{234Th}, ^{232}Th, ^{230Th}) were found to be of very low activity (< 5 mBq/L), much less than that of ^{226}Ra.

The take away message from this work is that disregarding the gradual growth in activity of radium daughter products for produced water in a sealed environment would lead to gross underestimates of the dangers of radioactive emissions presented by the fluid. Sealing the container of the produced water prevents escape of radon gas. The consequence is that after 15 days the radioactivity would be >5 greater than that based on Ra measurements alone; a continuous increase is predicted to a maximum of >8 fold about 100 years after extraction. It is especially important to consider the role of long-lived, environmentally persistent Ra decay products (^{228}Th, ^{210}Pb, ^{210}Po).