RWMA NEWSLETTER

Spring 2013

RADIOACTIVITY IN MARCELLUS SHALE:
Pennsylvania DEP Takes Notice.

Announcing the greatest, the most wonderful, the even 'better than sliced bread,' study on radioactivity in Marcellus shale, by… (drumroll): The Pennsylvania Department of Environmental Protection (DEP) through the company Perma-Fix Environmental Services, Inc. (PESI). PESI, who operates four nuclear waste treatment facilities, has been asked by DEP to write an objective report on the potential negative effects of drilling into Marcellus shale. This is like a candy shop writing a report about how sugar is bad for children. In this newsletter report we critique the proposed study.

It is no secret that Marcellus shale is radioactive. Drilling logs by gas companies and reports by USGS show that radium concentrations are up to 32 times surface concentrations. Drilling and natural gas production brings this radioactivity to the surface in the form of rock cuttings, drilling fluids, flowback water and brine, and radon gas. A fraction of drilling fluid will be recycled, reinserted into deep disposal wells, or go to water treatment plants. The rock cuttings will go to solid waste landfills. Over the production cycle, a portion of Marcellus radium will plate out on pipes. And an inert radioactive gas, radon, will enter homes when natural gas is used for heating and cooking (Resnikoff 2012).

This is not alchemy, where lead is magically turned into gold, or in the case of Marcellus shale, where radioactivity below ground, magically disappears when brought to the surface. So we greatly anticipate what PESI has to offer.

So why has the Pennsylvania DEP just recently jumped into the game? It is now three years after RWMA produced a report on radium in Marcellus for RFPLC (Resnikoff et al. 2010), now 32 years (Leventhal 1981) or 53 years (Swanson 1960) after the USGS researched radioactivity in Marcellus shale, and years after the gas industry has drilled over nine thousand wells into Pennsylvania shale (with over 3,000 recorded drilling violations on-site; www.stateimpact.npr.org). We surmise

the timing of DEP's study is because the drilling of Marcellus shale is a current hot debate, with heated public resistance in New York, Pennsylvania, Ohio and West Virginia, where the shale formation lies beneath the Earth's surface. In short, we smell a whitewash.

In this report we discuss the fate and transport of radioactive materials when Marcellus shale is brought to the surface. We also critique the proposed DEP study.

Waste-Water

The process of hydro-fracking, used to obtain natural gas from the Marcellus shale, requires a large quantity of water to complete the process- over 3 millions gallons of water per treatment (Harper 2008), to be exact. Drilling fluid is used to remove the rock cuttings from horizontal wells in the Marcellus shale formations and to transport the drill cuttings to the well surface (Resnikoff et al. 2010). This water is recovered from the well, along with added liquids and chemicals throughout the fracking process and any produced formation brines from the drilled well. New York DEC sampled flowback water from vertical Marcellus shale wells and found that the liquid contained radioactive concentrations as high as 267 times the limit for discharge into the environment and thousands of times the limit for drinking water (Davies 2009). Brine from horizontal drilling, as being done throughout Pennsylvania, will be much more radioactive, quoted by New York DEC as high as 15,000 pCi/L (Resnikoff et al. 2010).

There is now even additional concern that radioactive materials contained within the Marcellus Shale are going to move to the Earth's surface in locations where fracking operations are not occurring, due to weakened shale structure from distant hydro-fracking operations. This concern is a serious one, since leakage of radioactive materials could enter natural aquifers and be contaminating drinking water reservoirs. A study, described in ProPublica May, 2012, modeled the movement of fracking fluid over time. The models predict that fracking will dramatically speed up the movement of chemicals injected into the ground. Fluid traveled distances within 100 years that would take tens of thousands of years under natural conditions. And when the models factored in the Marcellus' natural faults and fractures, fluids could move 10 times as fast as that. The report also stated that, "Where man-made fractures intersect with natural faults, or break out of the Marcellus later into the stone layer above it, contaminants could reach the surface areas in tens of years, or less" (Lustgarten 2012).

A stream is lit on fire from fracking pollution in Pennsylvania.
www.cleanwateraction.org

Mark Engle, a USGS geologist, says that both the Marcellus shale itself and the wastewater generated from fracking are both radioactive. He said that the radioactivity in Marcellus shale "may be fairly small, since radium is so soluble". But he also said that this solubility would make it easier for the radium to dissolve into the brine itself- and come to the surface (Soeder & Kappel 2009). Radium-226 will preferentially dissolve in the drilling fluid under the pressure and temperature conditions below ground (Resnikoff et al. 2010). While drilling fluid can be partially recycled, radium will progressively concentrate in it after each reuse.

State governments, like Ohio, say their hands are tied in regulating NORM from drilling operations due to the Cheney Amendment. Also known as the Halliburton Amendment, this loophole can be found in the Energy Policy Act of 2005. This amendment exempts the fracking process from federal oversight under the Safe Drinking Water Act of 1974 and exempts companies that are doing Marcellus shale drilling from having to meet the requirements of the Clean Water Act (Phillips 2011). "Due to federal exemptions, drilling occurs in close proximity to residential zones, elementary schools, playgrounds, hospitals, and public places; and citizens have no recourse," said Shane Davis, Sierra Club Rocky Mountain Chapter's Oil & Gas Campaign Information & Research Manager (Swain 2012). However, in our non-legal opinion, State governments can regulate technically-enhanced NORM, also known as TENORM. Recycling is such a process that enhances NORM. Fracking itself, the process of creating fractures in shale, increases the rock surface area and the solubility of radium, thereby producing TENORM. While this will be a matter for the courts to decide, it is clear to us that

the States can regulate TENORM and therefore this method of gas production.

Following the fracking operation, about 40% of the drilling fluid and residual water in the drilled well is removed; this is called flowback water. To throw some numbers out to clarify the amount of flowback water that needs to be managed, 1.3 billion gallons of radioactively-contaminated water produced between 2007 and 2010 was sent to sewage treatment plants in Pennsylvania (Resnikoff 2012). There is little data available regarding just how much radioactivity was managed, as most sewage plants in the State are neither equipped to remove radioactive material, nor even required to monitor for radioactivity.

Documents obtained by the Environmental Protection Agency (EPA) reveal that wastewater, which is sometimes hauled to sewage plants not designed to treat it and then discharged into rivers that supply drinking water, contains radioactivity at levels higher than previously known, and far higher than the level that federal regulators say is safe for these treatment plants to handle (Urbina 2011). Most of these facilities cannot remove enough of the radioactive material to meet federal drinking-water standards before discharging the wastewater into rivers, sometimes just miles upstream from drinking-water intake plants. In Pennsylvania, these treatment plants discharged waste into some of the state's major river basins. Great amounts of wastewater went to the Monongahela River, which provides drinking water to more than 800,000 people in the western part of the state, including Pittsburgh, and to the Susquehanna River, which feeds into Chesapeake Bay and provides drinking water to more than six million people, including some in Harrisburg and Baltimore (Urbina 2011). And sometimes, a wastewater treatment plant is bypassed altogether and the radioactive materials are simply just dumped down the sewer (Morgan 2013). Unfortunately, "there are business pressures" on companies to "cut corners", said John Hanger, who stepped down as secretary of the Pennsylvania Department of Environmental Protection in January of 2011. "It's cheaper to dump wastewater than to treat it," he added (Urbina 2011).

Now consider this- New York DEC estimates 1600 drilling applications per year, with each horizontal well producing between 2.4 million and 7.8 million gallons of flowback water. This would result in 3.8 to 12.5 billion gallons of contaminated water per year that has to be treated. Under the proposed DEC regulations (NYDEC 2010), a drill applicant must have a plan to deal with flowback water and brine. Despite regulations, it is not clear whether municipal water treatment plants can handle the magnitude of the radioactive waste problem posed by flowback water and brine.

In addition to flowback water, during well production, radium-contaminated brine is brought up with natural gas. The brine itself is separated at the wellhead and has to be managed and disposed of in some manner. Sampling of brine materials to date has shown very high radium concentrations (NYDEC 2011). The radium concentrations in brine range up to 3,000 times the defined safe drinking water limits of 5 pCi/L. While nobody is drinking brine, this water needs to be handled and disposed of in some way. A common method for Pennsylvania is to ship it off to Ohio in trucks or barges, to dispose in deep wells.

Landfills

The recovered solid rock cuttings from drilled wells, suspended in a mixture of drilling fluid and formation water with elevated radionuclide content, are placed on shale shakers and dewatered before disposal into a landfill. However, not all of the liquid waste in which the drill cuttings are suspended will be removed. Drill cuttings and other materials associated with oil and gas have triggered radiation monitors at landfills (PA DEP Press Release 2013). Radium-226 has a half life of 1600 years and, if deposited in a landfill (or any other general area due to incorrect wastewater treatment), will remain there and eventually leach out essentially forever ((Resnikoff et al. 2010)). Occasionally, trucks carrying rock cuttings have triggered radiation detection devices, portal monitors, and been turned away. In mid April, a truck loaded with Marcellus shale drill cuttings that triggered a radiation alarm at a hazardous waste landfill in South Huntingdon, Pennsylvania was ordered back to a Greene County drilling site (Peirce 2013). However, where these cuttings then end up is often undocumented and unclear. This is an issue that puts people at a risk for ingestion and inhalation of carcinogenic NORM due to exposure in the work place, through crops grown on polluted soils, through livestock raised on contaminated land and just general exposure through everyday activities with potentially un-monitored radiation in an area.

An Issue That Hits Home

Cows graze where a frack water pipe traverses a field in Pennsylvania
Brian Cohen/Marcellus Shale Documentary Project (Courtesy of: stateimpact.npr.org)

Communities and homeowners are already feeling the effects of hydro-fracking and well drilling across the reaches of the Marcellus shale formation. Landowners are presenting symptoms, rashes and illnesses believed to be caused by exposure to drilling fluid chemicals in their drinking water from drilling activities that have taken place on or near their land, as described in these recent articles (Peeples 2012; Corrado 2012; Petracca 2013). One doctor was quoted as saying, "There is an epidemic of rashes occurring in Pennsylvania" (J. Skinner, personal communication, February 14, 2013). With the amount of acute health issues popping up throughout Pennsylvania, believed to be in response to drilling practices, we have concern this is just the tip of the iceberg when radium eventually leaches out of landfills. When ingested, radium concentrates in bone and can increase the probability of leukemia.

At the present time, there has not been enough independent research regarding radium concentrations in material being deposited in landfills and sent to water treatment plants to deem either of these processes as safe and/or plausible. It also should be noted that drilling contamination is entering the environment in Pennsylvania through spills, too. In the past three years, at least 16 wells whose records showed high levels of radioactivity in their wastewater also reported spills, leaks or failures of pits where hydrofracking fluid or waste is stored, according to State records (Urbina 2011).

Scale in Pipes

During the production of natural gas, radium that is dissolved in water is brought to the surface. Scale, mostly radium sulfate, plates out on the surface of production pipes. This means that all equipment near the wellhead associated with natural gas production could exhibit a build up of radioactive scale: production pipes, water and gas separators, feeder lines and condensate tanks. Workers and the general public in close proximity to these pipes and equipment have an increased risk of developing cancer due to direct gamma exposure, like an x-ray machine that cannot be turned off. Additionally, workers at, and residents near, pipeyards that clean pipe scale will be at risk of exposure to radioactive materials through inhalation of the scale dust. Occasionally these pipes have been released for use by the general public, for fencing or for playgrounds. Production pipes have been cut up and welded, releasing radium scale for potential ingestion and direct gamma exposure by the public.

Pile of used gas pipes with NORM build-up (scale) in Texas.
Photo credit: Marvin Resnikoff

Radon in Homes

Another significant risk to the public of radioactive exposure from Marcellus shale is that of radon exposure in homes. This hazard has the potential for large numbers of lung cancer among natural gas customers. Radon is present in natural gas from Marcellus shale at

much higher concentrations than natural gas from wells in other regions of the country such as Louisiana and Texas (Resnikoff 2012). This is because Marcellus shale is much closer to end users than gas from Louisiana and Texas, and radon has less time to decay as it's brought into metropolitan areas in New York and Pennsylvania. Radon has a half-life of only 3.8 days. Marcellus shale is also more radioactive than other gas formations. Being an inert gas, radon will not be destroyed when natural gas is burned in a kitchen stove, thus exposing people in the home to radon via inhalation. These factors will lead to increased cases of lung cancer with customers who are using the natural gas from Marcellus shale drilling wells. Radon from the Marcellus shale formation needs to be independently

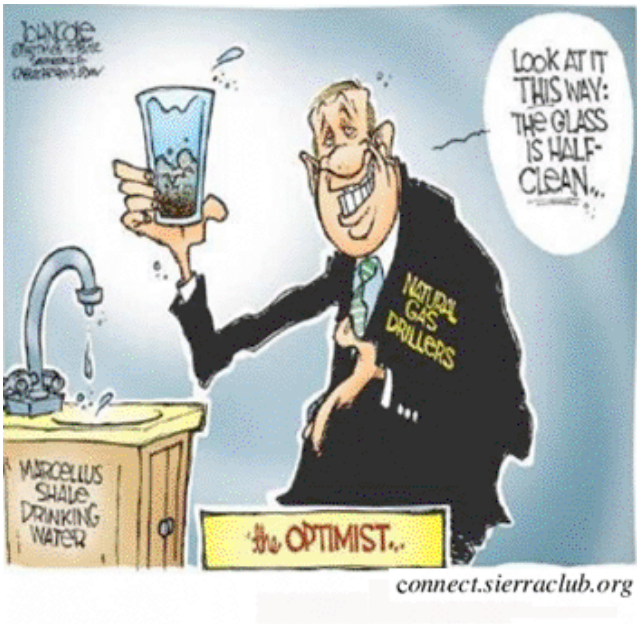
measured at the wellhead; how the natural gas is handled at processing plants and in storage must be thoroughly examined.

The bottom line is that the waste being generated, both solid and liquid, from drilling into and production from Marcellus shale, is radioactive and is being improperly managed to date. But, now at last, we have Pennsylvania DEP's Sampling and Analysis Plan, to clarify or muddy the waters.

"Those who have the privilege to know, have a duty to act." – Albert Einstein

Pennsylvania DEP Study

In April 2013, Perma-Fix prepared field sampling and quality assurance plans for the Pennsylvania DEP. These plans outline a "comprehensive study investigating the NORM and TENORM related to the oil and gas exploration activities including conventional and unconventional drilling through geological formation(s) and associated waste water operations throughout the Commonwealth of Pennsylvania (PA)." This ambitious study presents a wide array of components associated with drilling activities and includes an evaluation of TENORM in ambient air, drilling cuttings, natural gas, natural gas processing pipes and equipment, waste water generated on drilling sites, sludge resulting from the processing of waste water from the well pad development process and landfill leachate. The sampling outline for this study is also extensive, including samples of/from: vertical and horizontal drill cuttings, onsite pits containing cuttings, production water, flowback water, filter socks, filter presses, compressed gas lines, off gassing, well pads, centralized impoundments, waste was facility sludge, waste water facility influent and effluent water, piping and casing scale, vapor capture systems, fresh proppant sands and drilling muds.



As mentioned in the initial introduction of this article, Pennsylvania DEP contracted the work for this study to Perma-Fix Environmental Services, Incorporated (PESI). According to PESI's website, the company describes themselves as a "nuclear services company and leading provider of nuclear waste management services". With a company so invested in the storage of nuclear waste, it is a stretch to judge the accuracy of a produced report that is, in essence, investigating the potentially great impacts that this waste can have on a population and environment.

The proposed study, briefly introduced above, appears to be exceedingly comprehensive. Overall, the components outlined in the sampling and analysis plan cover the majority of measurements and samples that need to be taken throughout the State of Pennsylvania to accurately assess the current drilling of Marcellus shale. The list of components to be sampled is very encompassing in approach, however it introduces questions regarding the completion time and research funds associated with this project.

The study sampling outline discusses the sampling of many different sites and equipment, most of which is on land that is not on public land. The plan is not forthcoming on how PESI field personnel will gain access to private sites in the field. Does PESI have the freedom to choose any site in the field, or will DEP, with industry's approval, designate specific sites? If not granted access, what will the alternative plan be? This leads to contact with all landowners and oil companies associated with each drilling location to be sampled. Activity logs for each site from the time that this sampling plan was released until the time of project completion would be important to understand whether any remediation efforts took place before the sampling was conducted.

Sampling strategy for the Pennsylvania DEP study is discussed regarding what factors will be assessed and how they will be evaluated. What is not described in great detail is the background process involved in selecting the wells to be assessed in the study. Each well needs to pass a list of required criteria in order to be considered for the study, however additional information as to how the wells were selected from there on out is lacking. Once passing criteria requirements, was selection of the wells random?

There is a lot of discussion throughout the report focusing on surface scans at drilling sites. Page 20 of the report discusses outline sampling methods saying that, "Subsurface sampling, i.e. by auger, will be considered when a gradient in the media sampled is suspected and the volume of material represented is not homogenous." It then goes on to say that each segment will be field screened

for gross gamma activity and if materials are above ambient background levels, a sample will be collected and sent to the lab for appropriate analysis. But, very specifically, there is no mention of push probe samples taken on site unless surface scans give reason for researchers to believe that there may be radioactive material in the vicinity. This is an important issue; for NORM materials, a one foot earth cover will reduce gamma emissions to 2% of uncovered readings. In our experience, push probes of covered drill ponds have detected radium-226 concentrations several times background.

There is also repeated mention of "cutting samples" removed from a "closed site". It is unclear exactly what methodology for these types of samples will be used. In our experience, radium scale builds up over time. Scale in production pipes that have been in use for over five years will have radium concentrations over a thousand times background. We raise the question, will PESI continue to sample used production pipes over time? Aside from the DEP study, an important question is, what will occur with these radium-contaminated pipes, how will they be managed? And again, this also raises concerns of accessibility and whether or not all sites will be readily accessible for samples to be taken.

In order to contain costs, all laboratory samples will be sent to DEP's radiological laboratory and also to "off-site laboratories for analyses." In our experience (*click for detail*), it will not be easy to find a laboratory that is not beholden to the oil and gas industry, whose future business will be threatened by unfavorable results. That is to say, though the PESI plan is, on its surface, ambitious and objective, it will fail public scrutiny if the labs cannot be trusted.

Throughout the DEP report, sampling efforts consist of measuring radon levels via aquatic sampling stations set up downstream of waste water treatment facilities. There is no further discussion of any other radon samples throughout the report. Radon should be measured not only at the mentioned downstream locations near waste water treatment facilities, but also at the actual on-site wellheads. The amount of radon detected at each wellhead location could be a valuable and important piece of research data that is currently not represented in the sampling plan.

The sampling proposal and research questions driving this Pennsylvania DEP report are good and headed in the right direction. However, some aspects require additional information and details to clarify the study approach to ensure that the results achieved are scientifically objective and pass the public smell test.

It is important to point out that DEP is not proposing a health study. This is a sampling and quality assurance plan. Many Pennsylvania residents near drill sites have developed rashes that must be due to the chemicals used in drill fluids and cannot be due to radioactivity which involves a latency period before the onset of cancers. DEP should also commission an objective epidemiological health study to determine if the health of residents is being affected by drilling operations. DEP should also commission a study of leukemias and other cancers over time.

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