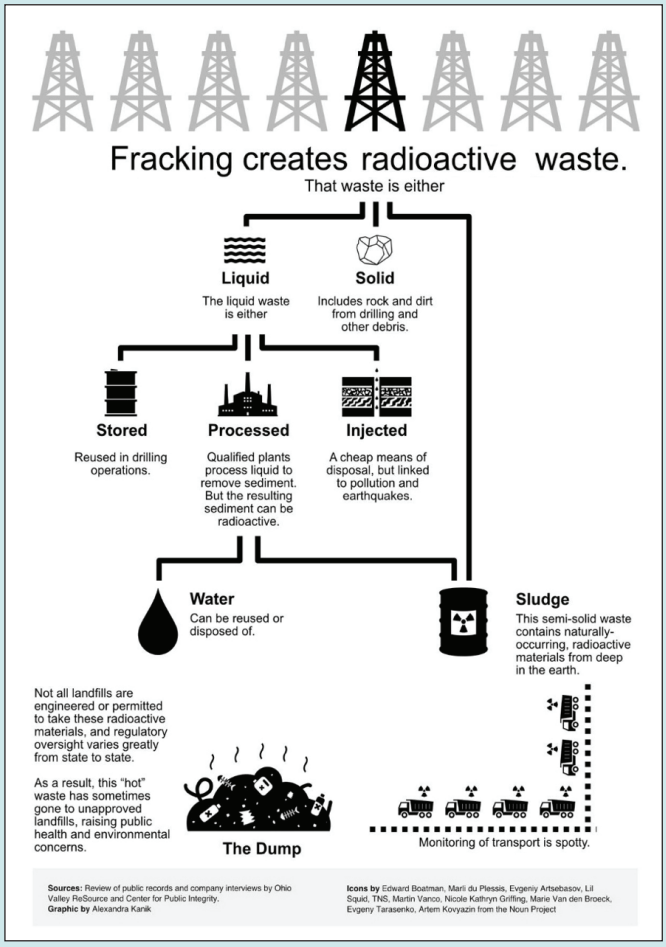
SOUTHWEST PENNSYLVANIA ENVIRONMENTAL HEALTH PROJECT

Risks to Water from Shale Gas Development

TYPES OF SHALE GAS WASTE (FRACKING WASTE):
Shale gas waste refers to waste produced by the extraction of oil and gas during hydraulic fracturing.

- **Solid:** Solid waste includes drill cuttings and sand.
  - Drill Cuttings: ground up rock pulled up from formation after drilling.
  - Sand (Proppant): fine silica sand used to keep fractures open to allow natural gas/oil extraction.
- **Liquid/Sludge:** Drill mud, hydraulic fracturing fluid, produced water, and flowback make up liquid/sludge waste. It is either reused in drilling, treated, or injected underground.
  - Drill Mud: water, clay, and chemicals used in the initial drilling process to lubricate the drill bit, flush the drill cuttings to the surface, and prevent overheating.
  - Flowback: combination of hydraulic fracturing fluid and produced water that returns to the surface.



TERMS TO REMEMBER:

- **Hydraulic Fracturing Fluid (HFF):** mixture of approximately 92% water (base/carrier fluid), 7% silica sand, and less than 1% is other chemicals/additives used to aid in the extraction of shale gas.[3] Examples of additives are: ammonium compounds, ethylene glycol (antifreeze), aldehydes, and hydrochloric acid.
- **Produced Water:** water found in the shale rock formation. Contains high amounts of salts (brine), radioactive materials, inorganic and organic compounds, and various gases. As of 2012, 890 billion gallons of are produced annually, about 2.44 billion gallons per day.[16]
- **Flowback Water:** combination of HFF and produced water that returns to the surface during gas extraction.
- **Volatile Organic Compounds (VOCs):** organic compounds that can be carried by water but vaporize (become a gas) easily when exposed to air. Common VOCs include benzene, toluene, ethylbenzene, and xylene (known as BTEX).
- **Naturally Occurring Radioactive Materials (NORMs):** radioactive compounds found throughout the Earth's crust. Some common NORMs are Uranium, Thorium, Radium, Radon gas, Polonium-210, and Lead-210.[20]
- **Technically Enhanced NORMs (TENORMs):** created when NORMs are brought up to the surface and concentrated by man-made processes, such as shale gas extraction. TENORMs pose an occupational and public health hazard.[20]

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Courtesy of Lynn Anderson, Frack Free Mahoning, & Jean Engle, Youngstown Community Bill of Rights Committee. FracTracker Alliance

Hydraulic fracturing requires large volumes of water which are made toxic both by what is added for use by industry and by materials in the shale that are carried by the fluid back to the surface during the process of extracting shale gas. Between 1991 and 2017, shale gas development produced 398 million barrels of liquid waste, and 7 million tons of solid waste from 2010-2017.[7]

MODES OF WATER CONTAMINATION

There are several ways in which contamination of water can occur throughout shale gas development.

Cracked Well Casing: Casings are steel pipes surrounding the wellbore (drilled hole) which are encased in cement to protect groundwater sources from contamination. If the well casings or cement crack or became damaged, VOCs, natural gas (methane and ethane), and produced water may contaminate aquifers and underground drinking water sources.[5]

In a 2013 study conducted by Jackson et al, 144 drinking water wells in northeastern PA were tested for various gases that appear in the fracking process. Researchers found that 82% of drinking water wells were contaminated with methane, with average concentrations being six times higher, and ethane concentrations were twenty-three times higher if the drinking water well was within 1km of a shale gas well.[11]

Spills: Spills of flowback may occur due to holding facility malfunctions, or equipment accidents resulting in surface water contamination.

1,209 spills were reported in PA between 2005 to 2014, mostly from transportation or storage facility spills.[14]

Dumping: Illegal dumping of waste water has also been documented.

The owners of Hallstead Sanitary Services Inc. were charged with tampering of public records and unlawful conduct when they were caught dumping radioactive waste into farm fields in Susquehanna County from January to March in 2010. They also forged paperwork sent to the EPA to make it seem like they were sending their waste to a proper disposal facility, when the facility in question stopped accepting sludge disposals in 2006.

WASTEWATER DISPOSAL

Some common ways to store and dispose of flowback water are:

- Reuse/Recycling
- Pits/Impoundments, Evaporation pits (discontinued in PA as of 2016)
- Underground Injection Control Class II injection wells
- Surface spreading
- Wastewater treatment plants

Reuse/Recycling: Reusing wastewater has been practiced since 2008 to enhance hydrocarbon recovery at production wells, along with saving money on disposal and storage. As of 2013, 69.1% of all unconventional wastewater was reused. As of 2015, 90% of all unconventional operators in PA reused wastewater in oil and gas fields as a wastewater handling practice.[6]

Pits/Impoundments: Solid waste, liquid waste, and freshwater reserves are stored in pits and impoundments for treatment and reuse. It is unclear how many impoundments are used for toxic wastewater or freshwater, but several companies have been fined for misusing their freshwater impoundments for wastewater, and for contaminating soil and water supplies due to leaks and ripped liners. There were inconsistencies in operator reporting of surface impoundment use in 2003, 2007, and from 2009-2016, when ground conditions show that they have been used since before 2009.[6]

- *EQT was fined $4.5 million in 2014 for leaking 300-500 gallons of flowback fluid out of an impoundment pond into local water sources and soil.[4]*
- *Range Resources was fined $4.1 million for 6 impoundment violations in Washington County in 2014.[4]*

Underground Injection Control Class II Wells: UIC Class II wells are also known as brine disposal wells or deep injection wells (DIWs). UIC Class II wells can hold any fluid produced from shale gas wells. The flowback water is sent thousands of feet underground into rock formations. Much of PA wastewater is sent to other states for storage and disposal. There are 8 active and permitted DIWs in PA as of 2018, with five UIC well applications being approved by the DEP within the last 12 months.[6] Several more are being proposed in the next few years, despite previous claims that PA geology is not suitable for DIWs.[10] Contamination of water, soil, and air can occur if a DIW malfunctions. In addition, earthquakes have been linked to DIWs in PA, reaching magnitudes of 4.0 on the Richter scale.[7]

- *Within a year of a NorthStar Class I injections well being built in Youngstown, OH, 109 earthquakes were recorded in and around the town.[7]*

Morrow Co. Ohio Fishburn Walter Class II Well. Courtesy of Ted Auch, FracTracker Alliance, Sept 2015

Surface Spreading: PA uses brine as a deicer and dust suppressant on roads. Unconventional shale gas flowback use on roads is prohibited in PA while conventional shale gas brine was allowed until 2018.[8] Conventional fracking wastewater is different from unconventional wastewater in that there is a lower volume, but it is known to have similar contaminants as unconventional waste water.

- *Penn State conducted a study on conventional wastewater and found that it contains high amounts of salts, radium, and lead that can stick to roadways or leech out into the ecosystem.[8]*

Wastewater Treatment Plants: In 2016, the EPA finalized a rule under the Clean Drinking Water Act banning the disposal of waste from unconventional oil & gas operations at publicly owned sewage treatment facilities to help prevent public water contamination of salts, radioactive compounds, and various metals.[9] Yet privately owned treatment facilities are still treating shale gas wastewater. The EPA's research supported the ban, showing that publicly owned treatment works are not designed to treat high concentrations of total dissolved solids, radioactive constituents, metals, chlorides, sulfates, and other toxic compounds found in shale gas extraction wastewater.[15]

The acceptance of shale gas wastewater by publicly owned treatment works (POTWs) was phased out by 2012. Centralized wastewater treatment facilities (CWTFs) were phased out from 77.9% of acceptance in 2009 to 0.3% in 2017.[6]

RISKS OF THESE EXPOSURES

Exposure to the chemicals found in hydraulic fracturing fluid, produced water, and flowback water can have detrimental effects on human health, especially in developing fetuses and children. Many of the additives and compounds brought up to the surface have been shown in studies to be cancer causing, disrupting of hormones, and radioactive.

- *In a study conducted by the Environmental Protection Agency, 134 chemicals were detected in produced water. Of these 134 chemicals, 70 of them were considered toxic if ingested, and were known to cause cancer, immune system complications, and were known to be toxic to the heart, nervous system, liver, kidneys, and to reproduction and development.[19]*

- *A study in PA found pregnant mothers living closer to unconventional natural gas wells were more likely to have infants that were small for gestational age with lower birth weights compared to infants from mothers living farther from wells. [18]*

- **Toxic Pollutants:** Many additives used in shale gas development are known irritants, and are toxic even at very low levels. Some commonly used additives are ethylene glycol (antifreeze), hydrochloric acid, and glutaraldehyde. Exposure to ethylene glycol can lead to damage of the central nervous system, heart, and kidneys, and can be fatal without treatment.[22] Chronic exposure to hydrochloric acid can result in long term respiratory damage.[21]

- **Metals**: Various metals found deep underground are brought back up to the surface, contaminating soil and water. For example, barium is known to cause increases in blood pressure.[13]

- **BTEX:** Benzene, toluene, ethylbenzene, and xylene are known to be cancer causing and toxic to the nervous system and various organs.[13]

- **Radioactivity:** NORMs are brought to the surface during shale gas extraction. Contamination of soil, water, and air can occur if a spill or improper disposal/storage occurs. NORMs can cause cell abnormalities, leading to various cancers. For instance, Radium-226 gives off harmful radiation known to cause lymphomas, leukemia, and bone cancer when ingested or exposed.[2]

  - *A Duke University study was conducted at the Josephine Brine Treatment Facility in PA to measure the radioactivity levels of the sediments downstream. It was determined that radiation levels were two hundred times higher than normal. Bioaccumulation of radioactivity in food, health effects to the environment, and human health effects are the primary concerns.[23]*

Treated oil and gas wastewater flows into a western Pennsylvania stream. (Photo: Avner Vengosh, Duke)

WHY ARE THESE EMISSIONS ALLOWED?

In 2005, Congress provided exemptions for the shale oil and gas industry in the Safe Drinking Water Act, known as the Halliburton Loophole. Previously, fracking with diesel without a permit was prohibited because of its toxicity. However, many compounds more toxic than diesel are allowed in the fracking process currently. In addition, full disclosure of fracking chemical make-up and quantity is not required. So, if contamination were to occur, exposure to unknown chemicals could endanger people who live nearby.[17]

Another aspect of water contamination that is often overlooked is the fact that private water wells are not regulated by the PA Department of Environmental Protection (DEP). Determining well contaminants, well integrity, and water quality testing is up to the homeowners. Without frequent testing, contamination of groundwater could occur and the homeowner would never know, putting the health of the homeowner at risk.

The Resource Conservation and Recovery Act: Subtitle C exempted oil/gas waste as hazardous waste from hazardous waste regulations in 1980. Toxic wastewater can be discharged into surface water and solid waste can be put into landfills not properly testing for radiation. Shale gas waste is exempt from "cradle to grave" tracking from well site to disposal site. There's limited information on the number of disposal facilities that treat, store, and dispose of waste, leading to inadequate data of what happens to shale gas waste.[12]

SUGGESTIONS

To protect public health, exemptions in federal and state environmental laws should be removed. Waste from shale gas development should be recognized as toxic and radioactive and be disposed of properly.

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