PSE Healthy Energy

SCIENCE SUMMARY

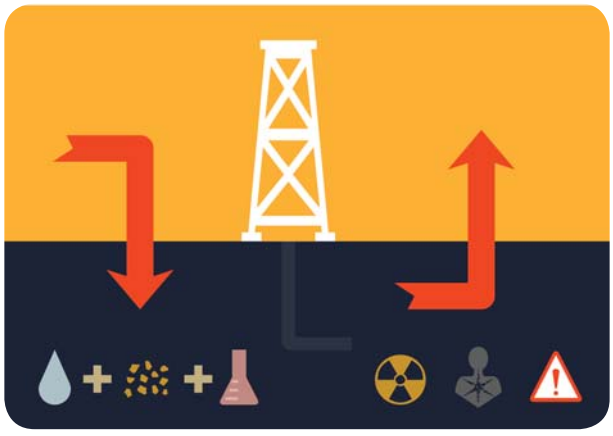
FEB 2015

The potential impacts of shale gas and oil development on children as a vulnerable population

Highlights

- Toxic chemicals are used in shale oil and gas development (e.g., hydraulic fracturing) and are present in generated wastes and byproducts.[1–5]
- Children and pregnant women can be exposed to these toxins through a number of environmental pathways, including air pollution and water contamination.
- Additionally, children may be exposed to other social and biological stressors associated with related heavy industrial activities, such as noise and light pollution.
- Research shows children are at a greater risk from exposure to environmental pollution.
- Initial research on adverse health outcomes in children in the context of shale gas and oil development is consistent with what we know about other environmental health hazards.

WHAT IS USED AND PRODUCED?



Used: FRACTURING FLUIDS

water + sand + chemicals

ethylbenzene, ethylene glycol, monobutyl ether, gluteraldehyde, xylene, hydrochloric acid, ethanol, methanol

Produced: WASTES + BYPRODUCTS

arsenic, lead, BTEX (benzene, ethylbenzene, xylene, toluene), radionuclides/radon, hydrogen sulfide, formaldehyde

Many of the toxic chemicals used and produced by shale gas and oil extraction processes have well known health effects. For instance, benzene is a known carcinogen, toluene is a neurotoxin, and hydrogen sulfide irritates the lungs and can cause asthma.

WHY ARE CHILDREN MORE VULNERABLE TO ENVIRONMENTAL EXPOSURES?

- smaller size and developing organ systems
- behaviors put them in close contact with the environment (e.g., play outside more, put things in their mouths)
- less able to metabolize and excrete chemicals
- receive proportionately larger doses of chemicals because of their surface body area
- longer shelf life for diseases with longer latency periods (i.e., have more years in life to be exposed)

Air Pollution

Air pollution from shale gas and oil development is a clear, well-defined pathway of exposure that is produced not only from activities in and around the wellhead, but also from the transportation of water, sand, and chemicals to and from the well pads, from separator tanks, compressor stations, and other ancillary processes. Studies suggest trucking and other activities deliver significant impacts not only on local air quality,[6] but also on regional air quality.[7] Air pollutants known to be health damaging have been measured in concentrations elevated enough to contribute to an excess public health burden for nearby human populations.[8–11] Emissions of health

damaging air pollutants such as nitrogen oxides (NO_x), volatile organic compounds (VOCs), aromatic hydrocarbons, particulate matter (PM), and ground level ozone (smog) precursors (e.g., VOCs, NO_x) occur throughout the life cycle of shale gas development. Benzene, a well known carcinogen, has been identified as a major contributor to elevated cancer risks from air emissions associated with the development of unconventional natural gas.[8] Intense, episodic events can trigger health symptoms and sensitize people and research suggests that measuring average exposure to air emissions may not adequately capture certain risks to human health.[12]

Water Contamination

Modern oil and gas operations have also been linked to surface and groundwater contamination with some of the toxins previously described (e.g., BTEX, heavy metals) on numerous occasions.[13–15] In Pennsylvania, 250 instances of impacted water supplies have been confirmed by the DEP to have resulted from oil and gas activities (as of 12/31/2014).[16] One study in Colorado examined water samples from areas with a high spatial density of natural gas activities and found significantly higher endocrine disrupting activity compared to areas with limited development.[15] Endocrine disrupting chemicals present unique hazards, particularly during fetal and early childhood growth.[17] These chemicals can produce adverse developmental, reproductive, and immunological effects and lead to pathology decades after exposure.[18]

Epidemiology

While the body of scientific literature examining the direct impact of shale gas and oil development on children is now only beginning to emerge, it is well established that children are more susceptible to environmental pollutants. There are a number of studies that have examined health outcomes of various pollutants and toxins in children. For instance, some ecologic studies have identified an association between hazardous air pollution and childhood leukemia,[19] while others have looked at the appearance and exacerbation of asthma and other respiratory illnesses from environmental exposure to ozone, particulate matter, and nitrogen oxides.[20–22] A study using personal monitoring data found an association between maternal benzene exposure from air pollution and decreases in birth weight and head circumference during pregnancy and at birth.[23] Another study using a birth defects registry found an association between benzene exposure and spina bifida, a neural tube defect in newborns.[24]

The potential for adverse health outcomes in children has inspired research in the context of oil and gas development. Initial results have been consistent with the existing body of epidemiology that observes the impact of air pollutant exposure on children more generally. Notably, a study in Colorado examined associations between material residential proximity to natural gas development, and found a positive association in the prevalence of congenital heart defects and possibly neural tube defects in newborns.[25]

References

1 Stringfellow WT, Domen JK, Camarillo MK, *et al.* Physical, chemical, and biological characteristics of compounds used in hydraulic fracturing. *Journal of Hazardous Materials* **2014**;275:37–54.
2 Aminto A, Olson MS. Four-compartment partition model of hazardous components in hydraulic fracturing fluid additives. *Journal of Natural Gas Science and Engineering* **2012**;7:16–21.
3 Alley B, Beebe A, Rodgers Jr. J, et al. Chemical and physical characterization of produced waters from conventional and unconventional fossil fuel resources. *Chemosphere* **2011**;85:74–82.
4 Colborn T, Kwiatkowski C, Schultz K, et al. Natural Gas Operations from a Public Health Perspective. *Human and Ecological Risk Assessment: An International Journal* **2011**;17:1039–56.
5 Maguire-Boyle SJ, Barron AR. Organic compounds in produced waters from shale gas wells. *Environ Sci: Processes Impacts* **2014**;16:2237–48.
6 Colborn T, Schultz K, Herrick L, *et al.* An Exploratory Study of Air Quality Near Natural Gas Operations. *Human and Ecological Risk Assessment: An International Journal* **2014**;20:86–105.
7 Kemball-Cook S, Bar-Ilan A, Grant J, et al. Ozone Impacts of Natural Gas Development in the Haynesville Shale. *Environ Sci Technol* **2010**;44:9357–63.
8 McKenzie LM, Witter RZ, Newman LS, et al. Human health risk assessment of air emissions from development of unconventional natural gas resources. *Sci Total Environ* **2012**;424:79–87.
9 Gentner DR, Ford TB, Guha A, et al. Emissions of organic carbon and methane from petroleum and dairy operations in California's San Joaquin Valley. *Atmos Chem Phys* **2014**;14:4955–78.
10 Pétron G, Karion A, Sweeney C, et al. A new look at methane and non-methane hydrocarbon emissions from oil and natural gas operations in the Colorado Denver-Julesburg Basin. *J Geophys Res Atmos* **2014**;:2013JD021272.
11 Pétron G, Frost G, Miller BR, et al. Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study. *J Geophys Res* **2012**;117:D04304.
12 Brown D, Weinberger B, Lewis C, et al. Understanding exposure from natural gas drilling puts current air standards to the test. *Rev Environ Health* **2014**;29:277–92.
13 Fontenot BE, Hunt LR, Hildenbrand ZL, et al. An Evaluation of Water Quality in Private Drinking Water Wells Near Natural Gas Extraction Sites in the Barnett Shale Formation. *Environ Sci Technol* **2013**;47:10032–40.
14 Gross SA, Avens HJ, Banducci AM, et al. Analysis of BTEX groundwater concentrations from surface spills associated with hydraulic fracturing operations. *J Air Waste Manag Assoc* **2013**;63:424–32.
15 Kassotis CD, Tillitt DE, Davis JW, et al. Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region. *Endocrinology* **2013**;155:897–907.
16 Pennsylvania Department of Environmental Protection. Water Supply Determination Letters. **2014**.http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/Determination_Letters/Regional_Determination_Letters.pdf
17 Diamanti-Kandarakis E, Bourguignon J-P, Giudice LC, et al. Endocrine-disrupting chemicals: an Endocrine Society scientific statement. *Endocr Rev* **2009**;30:293–342.
18 Zoeller RT, Brown TR, Doan LL, et al. Endocrine-disrupting chemicals and public health protection: a statement of principles from The Endocrine Society. *Endocrinology* **2012**;153:4097–110.
19 Whitworth KW, Symanski E, Coker AL. Childhood Lymphohematopoietic Cancer Incidence and Hazardous Air Pollutants in Southeast Texas, 1995-2004. *Environ Health Perspect* **2008**;116:1576–80.
20 Rumchev K, Spickett J, Bulsara M, et al. Association of domestic exposure to volatile organic compounds with asthma in young children. *Thorax* **2004**;59:746–51.
21 Tzivian L. Outdoor air pollution and asthma in children. *J Asthma* **2011**;48:470–81.
22 Suwanwaiphatthana W, Ruangdej K, Turner-Henson A. Outdoor air pollution and children's health. *Pediatr Nurs* **2010**;36:25–32.
23 Slama R, Thiebaugeorges O, Goua V, et al. Maternal Personal Exposure to Airborne Benzene and Intrauterine Growth. *Environ Health Perspect* **2009**;117:1313–21.
24 Lupo PJ, Symanski E, Waller DK, et al. Maternal Exposure to Ambient Levels of Benzene and Neural Tube Defects among Offspring: Texas, 1999-2004. *Environ Health Perspect* **2011**;119:397–402.
25 McKenzie LM, Guo R, Witter RZ, et al. Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado. *Environmental Health Perspect* **2014**;122.