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Viewpoint

Distance: A critical aspect for environmental impact assessment of hydraulic fracking

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ABSTRACT

Public concerns about hydraulic fracking are growing and scientists continue to analyze and evaluate its associated environmental impacts. However, a rigorous spatial analysis of environmental impacts is necessary to provide a perspective on risk based on proximity to fracking wells. This comment describes the environmental impacts of fracking within a spatial context. It emphasizes five key points: (1) the closer to a hydraulic fracking well, the higher the risk of groundwater and drinking water well contamination; (2) residents living nearest to a fracking well experience a higher human health risk due to exposure to gas emissions during the fracking process; (3) huge and high density gas emissions are detected and recorded close to fracking wells; (4) fracking induces seismicity and small earthquakes are recorded close to fracking wells; and (5) hydraulic fracking directly changes local environment and landscape characteristics. Spatial impact assessments are critical for improving understanding of the impacts of hydraulic fracking on the environment and society.

1. Introduction

Hydraulic fracking, also called fracking, is the process of extracting natural gas from shale rock layers within the earth. Specifically, horizontal drilling combined with traditional vertical drilling allows injection of highly pressurized fracking fluids into the shale layers to create new channels within the rock, from which natural gas is released at much higher rates than traditional drilling. Hydraulic fracking yields more than one-half of US natural gas supply and is transforming energy supplies in the United States (Jackson et al., 2013). For example, in January of 2013, the daily production of methane in the United States was 2×10^9 m^3, more than a 30% increase from 2005 (USEIA, 2013). Fracking gas production in Northeastern Pennsylvania now exceeds 2 billion cubic feet per day, up from 0.4 billion cubic feet per day in early 2010. In Southwestern Pennsylvania, it is close to 1 billion cubic feet per day, more than three times the production of early 2010 (WhatIsFracking, 2014).

Environmental concerns about hydraulic fracking are growing (Osborn et al., 2011; Schmidt 2011). These concerns include changes in air quality (Petron et al., 2012), human health risks for populations living near fracking wells (Schmidt, 2011), and the potential persistence of pollutants in groundwater and drinking water in close proximity to hydraulic fracking sites. For example, hydraulic fracking from the Marcellus Shale in the Appalachian Basin of the Northeastern United States has raised concerns about potential environmental pollution (Kerr, 2010; Kargbo et al., 2010). Methane migration to groundwater, drinking water wells, and the atmosphere (Howarth et al., 2011a; Osborn et al., 2011; Jiang et al., 2011) is of particular concern. Additional concerns include induced seismicity associated with fluid injection into deep wells (Ellsworth et al., 2012), epicenters of small earthquakes within an approximate 1 km radius to the fracking well (Kim, 2013), and surface environmental and landscape changes (Meng, 2014).

Recent studies have failed to feature any rigorous spatial analysis but have suggested that spatial dimensions of environmental impacts exist, and are largely a function of distance to fracking sites. It is therefore time for decision makers and scientists to pay closer attention to the spatial planning of hydraulic fracking, prioritizing the issue of distance to a hydraulic fracking well in environmental impact assessments. This is imperative, given the rapid rise in number of sites and their close proximity to water supplies and communities.

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2. Distance is all-important

Residents living within 0.8 km from a gas well are at higher risks of health effects than residents living beyond this distance (Mckenzie et al., 2012). Mckenzie et al. (2012) and Coons and Walker (2008) found that significant gas emissions exist close to a gas well (<0.8 km). Methane concentrations in drinking water wells within 1 km of a gas fracking well can reach potential explosion levels (Osborn et al., 2011). Methane concentrations are six times higher and ethane concentrations were found to be 23 times higher at residences within 1 km of a shale gas fracking site compared with concentrations at distant residences, and additionally, propane was detected in water wells within approximately 1 km of a fracking well site (Jackson et al., 2013). Subsurface and surface pathways exist although specific pathways of methane migration are not easily identifiable. Traces of ethane (C_2H_6) with microbial methane (CH_4) and a range of C and H isotopic compositions of CH_4 indicated that sub-surface pathways exist and gas mixtures are found in groundwater (Revesz et al., 2010).

Vidic et al. (2013) carried out an important review of the effects of shale gas development on regional water quality. However, reviews of methane migration are limited and tell very little. For example, Vidic et al. (2013) reported findings from a study of 48 water wells for pre- and post-drilling water chemistry that showed no statistical differences in dissolved methane before or shortly after drilling, and distance to drilling sites was not found to be significant. However, the authors did not take into account that among the 48 water wells, at 16 of the sites, only drilling—and no fracking—had occurred. Furthermore, 28% of the 33 water supply owners who reported changes to their water supply after drilling were located within 3,000 feet (0.914 km) of a Marcellus gas well (Boyer et al., 2011).

Based on a series of studies conducted by the EPA and other scientists, Howarth et al. (2011b) concluded that 3.6–7.9% of lifetime shale gas production migrates to the atmosphere through venting or leaking over a well is lifetime and that 1.9% of the total gas production is emitted as methane through well completion. For example, methane emitted during flow-back was determined to be 6800×10^3 M^3 with a per day rate of 680×10^3 M^3 for a fracking well in Louisiana, and calculated to be 370×10^3 M^3 with a per day rate of 41×10^3 M^3 for a shale gas well in Texas. Caulton et al. (2014) identified and quantified large emissions with an average of 34 g CH_4/s (2.937 ton/day) per well from seven hydraulic fracking pads in the drilling phase. These emissions are 2–3 orders of magnitude greater than the estimates formulated by the US Environmental Protection Agency. This methane can migrate to soils and open water through both wet and dry deposition. More data and studies are needed, however, to identify specific pathways for methane migration and how it impacts local air and water quality.

Construction of hydraulic fracking wells alters the local environment and land surface. Land clearing, excavating and grading, pad construction, pipeline and utility installation, related road construction, sump hole excavation, and hydroseeding as well as soil stabilization are the main construction activities that impact the local landscape. These activities also result in a much larger area being impacted than a conventional gas or oil drilling well. Additionally, the excavation of natural gas and oil resources from shale typically requires much more water. In the fracking process, fluids are forced under high pressure into the well, and the shale surrounding the borehole is fractured in order to liberate more gas from the low permeability shale gas reservoirs.

Meng (2014) has modeled the impacts of hydraulic fracking based on environmental and landscape variables. Statistical diagnostics of spatial logistic regression models show that elevation, slope, and land cover are significant environmental and landscape variables. A location with steeper slopes is less likely to become a fracking site. Sites at higher elevations are more likely to be occupied by fracking wells.

3. Conclusion

Hydraulic fracking has the potential to cause significant impact to local environments and landscapes. The closer a site is to a hydraulic fracking well, the greater the hydraulic impacts associated activity will have on the surrounding environment. There is a higher probability of the groundwater and drinking water wells which are located within 1 km of a fracking having been polluted by gas and fracking chemicals. The risk to human health is especially high among populations located within 0.8 km of a fracking well. High density gas emissions typically persist in the surface air close to fracking wells, and small earthquakes have been detected close to a deep fluid injection well. It is time to pay attention to concerns in order to develop a more comprehensive understanding and assessment of the environmental impacts of hydraulic fracking.

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