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Review

A review on risk assessment techniques for hydraulic fracturing water and produced water management implemented in onshore unconventional oil and gas production

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HIGHLIGHTS

- Unconventional oil and gas production poses risks to water quality and quantity.
- Risk levels vary with unconventional oil and gas production stages.
- Spill and leakage data limitations are obstacles for meaningful risk assessments.
- Social factors should be included in assessing water quality and quantity risks.

GRAPHICAL ABSTRACT

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ABSTRACT

The objective of this paper is to review different risk assessment techniques applicable to onshore unconventional oil and gas production to determine the risks to water quantity and quality associated with hydraulic fracturing and produced water management. Water resources could be at risk without proper management of water, chemicals, and produced water. Previous risk assessments in the oil and gas industry were performed from an engineering perspective leaving aside important social factors. Different risk assessment methods and techniques are reviewed and summarized to select the most appropriate one to perform a holistic and integrated analysis of risks at every stage of the water life cycle. Constraints to performing risk assessment are identified including gaps in databases, which require more advanced techniques such as modeling. Discussions on each risk associated with water and produced water management, mitigation strategies, and future research direction are presented. Further research on risks in onshore unconventional oil and gas will benefit not only the U.S. but also other countries with shale oil and gas resources.

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Contents

1. Introduction

Oil and gas (O&G) resources can be classified as conventional or unconventional depending on the geological formation. Conventional deposits, sand and carbonates such as limestone, have high porosity that allows the fluids (O&G) to flow into the wellbores (Freyman, 2014; Scanlon et al., 2014; USDOE, 2013a). Unconventional O&G deposits are trapped inside rocks such as shale and tight sands, which have high porosity and limited permeability (Freyman, 2014; Scanlon et al., 2014). These characteristics make production difficult, requiring stimulation to allow O&G to flow to the wellbore at an acceptable rate (Scanlon et al., 2014). The technologies of horizontal drilling and high-volume hydraulic fracturing (HF) have been combined to achieve the flow of hydrocarbons resulting in recent growth in onshore unconventional O&G development. In the U.S. from 2011 to 2013, 95% of oil production growth and 100% of natural gas production growth came from the Bakken, Niobrara, Marcellus, Utica, Permian, Haynesville and Eagle Ford (Fig. 1) (EIA, 2014).

This paper focuses on the following four shale formations due to their contribution to the total unconventional O&G produced in the U.S.: Bakken (North Dakota), Barnett (Texas), Eagle Ford (Texas), and Marcellus (Pennsylvania). The Eagle Ford ranked first in unconventional

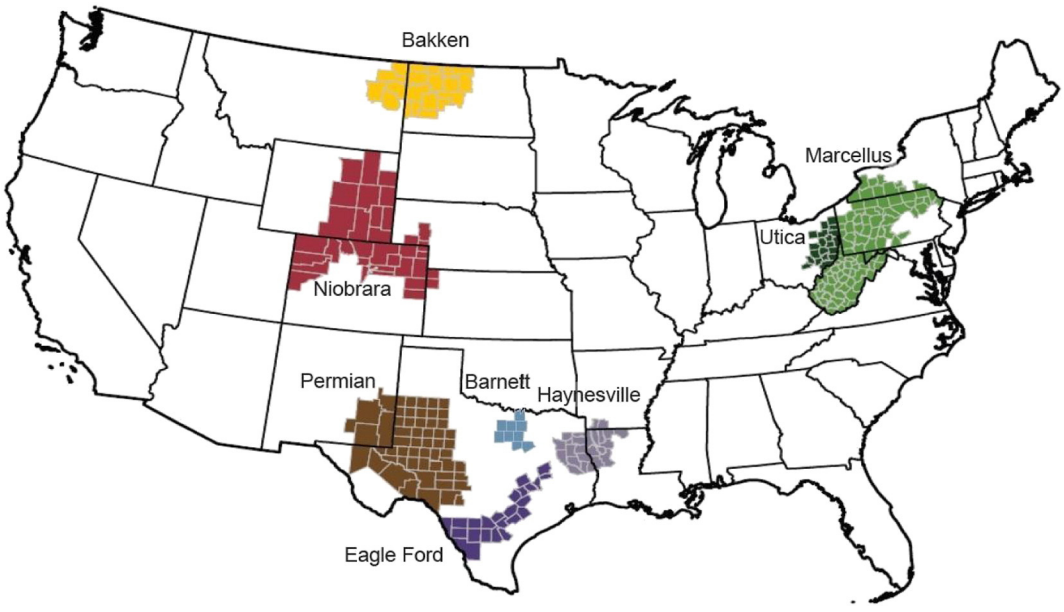

Fig. 1. Most important unconventional O&G regions (The blocks are counties.) in the United States. Adapted from EIA (2014).