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Research article

Perceived risks of produced water management and naturally occurring radioactive material content in North Dakota

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ABSTRACT

Unconventional oil and gas development using hydraulic fracturing has caused conflict and controversy across the globe including the U.S. where some States banned the practice. Nevertheless, North Dakota (ND) has supported the practice because the State perceives the risks to be acceptable and because it has brought growth and opportunities to small communities. However, social acceptance of new technology is based on a number of factors and not contingent on economic benefits. To date, no research has been conducted to understand public risk perception of hazards associated with produced water from hydraulic fracturing in ND. This study focuses on understanding the risk perception of select ND stakeholder groups regarding produced water management and naturally occurring radioactive material. The software Qualtrics was used to create an online survey, collect data, and perform statistical analysis. The most important variables that seem to influence risk perception are the images and thoughts associated with produced water, level of knowledge about produced water handling and content, and knowing how to proceed in case of a spill of produced water. Overall, social risk perception could be in alignment with actual technical risk if availability of objective information is improved.

1. Introduction

North Dakota (ND) developed its first successful oil well in 1951 and since then the State has become the second largest oil producer in the country and ranks 19th worldwide (North Dakota Petroleum Council, 2015). Sixty-five years have elapsed which makes oil production an old and well established practice in ND. However, the most recent oil boom and new drilling and completion techniques have resulted in controversy dividing the population between proponents and opponents for oil development (Brown and Yücel, 2013; Holeywell, 2011; Siegler, 2014).

Oil and gas (O&G) production in the U.S. has changed over the years, especially in ND. When oil was first discovered in the 1950's, it was welcomed by the State since there was a nationwide race to discover O&G during that time (Bluemle, 2001). However, oil production in the 1950's was limited because there was no supply shortage in the country compared to other decades, such as the 1970's crisis (Bluemle, 2001; History, 2010). Nowadays, O&G production using the unconventional methods of hydraulic fracturing and horizontal drilling have changed the way people see energy development in the country. Information availability has increased and people are more informed about the events occurring in their communities (Energy In Depth, n.d.; Western States Petroleum Association, 2013). This increase in awareness has resulted in relatively new and stricter environmental regulations regarding O&G compared to earlier development in the country (Kao and Gao, 1998; Kusnetz, 2012).

Unconventional O&G development requires the injection of millions of gallons of water with chemicals additives under high pressure. The injected water returns to the surface (flowback water) through the wellbore mixed with water that is naturally present in the reservoir (formation water). This mixture is called produced water which requires special management techniques for recycling or disposal due to its unique characteristics. Produced water contains constituents such as dissolved salts, organics, and naturally occurring radioactive material (NORM), and some of the constituents are known to affect human health and the environment if improperly managed (USEPA, 2012). Over the years, research has been conducted regarding contaminants in produced

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water and this information has become more publicly available (Energy In Depth, n.d.; Western States Petroleum Association, 2013). In addition, media coverage on accidents and spills related to oil development and production has increased (Maloney et al., 2017; Weber et al., 2014). These two factors, among others, have called the attention in ND and nationwide regarding the risks associated with produced water.

Risk perception cannot be directly measured in a quantitative way because it is based on different factors such as emotion, trust, values, knowledge, and experiences (Jones, 2012; Leiserowitz, 2005; Slovic, 2000). Different methods, including physical scaling and multivariate analysis, have been used to translate risk attitudes and perceptions into numerical measurements (Slovic et al., 1982). Surveys have been widely used in the past to collect data regarding risk attitude in different areas such as economics and psychology (Xiaohao et al., 2010). Surveys are effective tools to measure valid predictors of risk attitudes in real situations if designed appropriately and specific enough to collect more than general measures of concern (Xiaohao et al., 2010; Leiserowitz, 2005).

Previous research has attempted to understand the perception public and stakeholder groups have regarding energy development, including hydraulic fracturing. Surveys have been conducted at the state level, for example, in Pennsylvania, Ohio, and New York, and nationwide to collect public opinion data (Boudet et al., 2014). Data collected in these studies could be further analyzed by combining social and technical perspectives. In the past, risk analysis of new technologies has focused mostly on technical aspects leaving aside social aspects resulting in a narrow view of the real risks (Skogdalen and Vinnem, 2011). The results from social risk perception studies can be incorporated in risk assessments of O&G development to deliver holistic results that can be used to create appropriate safety measurements inside and outside the production fields. Here we refer to social risk perceptions as the ones created based on different dimensions including technical knowledge, psychological and social factors, and personal experiences (Leiserowitz, 2005; Slovic, 2000).

The holistic study of risks in oil development and production is particularly incomplete in ND where very little data on social aspects have been collected despite it is one of the largest oil producing states in the country. Among the few studies conducted in ND are Weber et al. (2014), which focused on social services, and Cwiak et al. (2015) which reported the thoughts, observations, and opinions of emergency management personnel about the direct and indirect impacts of oil production in the State. To our knowledge, no study on social risk perception in ND has focused on produced water, the largest by-product of oil production.

The number of produced water spills in ND has increased over the years with approximately 3900 reports since 2007 (Lauer et al., 2016). This increase is directly correlated with the amount of oil extracted (Lauer et al., 2016). In addition, most of the accidents in the exploration and production industry are caused by human error (Boschee, 2014). Here lies the importance of studying the social perception of produced water in ND because understanding how risk perception influences judgment and safety culture can lead to improved regulations and standards (Boschee, 2014).

The objective of this paper is to determine the risk perception and awareness of produced water management in different stakeholder groups in ND as well as to identify the most influencing variables that shape those perceptions. An online survey was developed using the web-based software Qualtrics (2016). The same software was used to collect and analyze the raw data obtained with the survey in order to understand the reasoning behind the perceptions that produced water management and contents have on people. The questions were aimed at four different stakeholder groups: general public, oil field operators, produced water hauling truck operators, and people whose jobs involve direct produced water management, decision making regarding health and safety, and/or emergency management personnel (hereinafter experts). The survey was distributed in numerous counties in ND including Cass County (where Fargo, ND is located) due to accessibility to North Dakota State University (NDSU) colleagues.

2. Methodology

2.1. Survey questionnaire development

The survey consisted of a questionnaire with 25 questions administered completely online. The survey was built using the Qualtrics online tool which in addition was used to collect the data, conduct the statistical analysis, and create reports. The NDSU Institutional Review Board approved this study including the survey (Certification of Exempt Human Subjects Research #EN 16,229). Most of the questions used a Likert scale from which the participants chose their answer. The Likert scale is a popular method used to measure attitudes and behaviors from one extreme to another (e.g. Not at all familiar to extremely familiar) (Losby and Wetmore, 2012).

The complete survey is available in Supplementary Material (SM). The first set of questions in the survey was used to collect demographic characteristics and the main source of information among the participants. Also, the general attitudes the participants had towards the economy of the State and information on whether they work or used to work in the oil field industry in ND were collected. In addition, the participants were asked to indicate if they know someone that works or used to work in the oil field industry. A section of the survey also focused on collecting affective imagery data by using the method of word associations (Leiserowitz, 2005). The participants were asked to rank (negative or positive) the initial thought or image that comes to their mind when they read “fracking wastewater” and “natural radioactive material.” This was done with the objective of analyzing the relationship between image perception and risk perception (Leiserowitz, 2005).

Later, the respondents indicated their level of awareness and familiarity with the contents and management of produced water, as well as, their level of concern with the associated risks. Moreover, the questionnaire included a section where participants indicated their level of trust in different organizations involved directly or indirectly with produced water management. Towards the end of the survey, participants were asked if their jobs involve responsibilities directly related to oil production and produced water management or if they were part of the emergency management personnel or a key response partner in ND. For the ones that responded negative, that was the end of the survey. Those who responded affirmative were categorized as experts and were redirected to further questions. Experts were asked to rank the level of awareness of the general public, the oil field operators, and the hauling truck operators about the risks of produced water. In addition, the experts were requested to gauge the risk perception of each stakeholder group on three different scenarios where produced water could reach a surface water body.

2.2. Survey testing and validation

The survey testing and validation process consisted of a pilot test. Four potential respondents, including colleagues of the authors and a layperson, were selected and asked to complete the survey. The most important aspects evaluated on the pilot test were completion time, wording, and questions accessibility (e.g. type of question such as multiple choice). Each respondent provided feedback on the content which was used to modify the questions