Fracking Forensics: Chemistry and Statistics in Environmental Litigation

by Roger G. Hanshaw, Ph.D
Bowles Rice LLP

I. The Steady Increase in Complexity in Environmental Litigation

A. The ages-old cause of action for common law nuisance has long been a bedrock of environmental litigation.1 However, as technology has removed many perceived and actual threats to human health and the environment from immediate human perception, the historical nature of environmental litigation has evolved to address much more than typical nuisance actions.2


B. The extractive natural resource industries are frequent targets of environmental litigation. Proper prosecution and defense of a case alleging environmental contamination must involve a thorough understanding of the science behind the allegations, including the laboratory and statistical methods employed by experts when formulating conclusions about causation or damages.

- Sanne H. Knudsen, Adversarial Science, 100 Iowa L. Rev. 1503 (May, 2015) (arguing that competing scientific conclusions developed in the context of litigation are important drivers of the truth-seeking function of litigation).


---

1 Common law causes of action based on nuisance have enjoyed a resurgence as tools for citizen-based enforcement of societal concerns, including environmental issues. For an overview of nuisance as a tool for citizen-based enforcement, see Thomas W. Merrill, Is Public Nuisance a Tort? 4 J. Tort L. 1 (2011).

2 Environmental litigation has steadily evolved from a common law-based approach to a highly-technical arena filled with statutory causes of action. For an account of the evolution of environmental litigation and its movement from a common law approach to the contemporary statutory environment, see Allan Kanner and Mary E. Ziegler, Understanding and Protecting Natural Resources, 17 Duke Envtl. L. & Pol'y F. 119 (2006).
expert witness testimony on health effects of exposure to hydraulic fracturing as inadequate under Daubert).

II. Evidentiary Issues Related to Determination of Contamination Sources

A. Extractive industries in general, and contemporary natural gas production in particular, involve many actors playing a variety of roles, both serially and in parallel. Proving an allegation of contamination from a part of the natural gas production process may require not only determination of an alleged contaminant, but also developing a link between the contaminant and one or more party involved in the production process. Likewise, defending against an allegation of contamination might involve offering evidence that an alleged contaminant is not derived from a defendant’s operation.

B. The fate of chemical compounds used in the drilling and completion process for newly-developed natural gas wells, especially those associated with shale formation development, is an active area of research. The primary literature continues to develop with examples of data suggesting examining the fate of compounds used in hydraulic fracturing, and many states are actively requiring the disclosure of chemical compounds used in well completion activities.


C. Presenting technical data as evidence in a case of alleged contamination poses several challenges, both from an evidentiary perspective and a technical

---

3 Well completion processes, including the specific chemicals and the ratios in which they are used, are typically considered proprietary information by most companies operating in the natural gas production industry. However, many states require public disclosure of chemicals used in hydraulic fracturing, and the fate and transport of these chemicals is an active area of research. As an example, see William T. Stringfellow, et al., Physical, chemical, and biological characteristics of chemicals used in hydraulic fracturing. 275 J. Hazardous Materials 37-54 (2014).

4 For a fairly comprehensive overview of state disclosure laws for hydraulic fracturing chemical use, see https://fracfocus.org/chemical-use/chemicals-public-disclosure (last visited April 1, 2017). Disclosure laws enacted by state have been the subject of litigation by well completion companies on the basis that disclosure amounts to a violation of intellectual property rights. These suits have generally had limited success. For an overview of state disclosure laws and an analysis of the legal basis for enactment of such laws, see Matthew McFeeley, Falling through the cracks: Public Information and the Patchwork of Hydraulic Fracturing Disclosure Laws. 38 Vt. L. Rev. 849 (2013-14).
perspective. Not only must the expert witness providing the testimony meet the *Daubert* standards, but the witness must also be able to educate the trier of fact on issues well outside the understanding of most lay citizens.

D. The issue of maintaining evidentiary standards in environmental litigation is also confronted in the administrative context. With the rise of the administrative state and the increasing extent to which technical issues are handled away from the courts and instead dealt with by administrative agencies, there is a growing consensus among practitioners that greater care must be taken to ensure that agency science is adequate when agency data is used as the basis for environmental enforcement actions.5


III. Chemical Fingerprinting – The Emerging Power of Environmental Forensics

A. The term “chemical fingerprinting” refers to a general class of analytical methods that can be utilized to differentiate one source of a chemical compound from other sources of the same compound.

B. Much like traditional fingerprint matching done by law enforcement officers to identify an individual, chemical fingerprinting relies heavily on statistics and probabilities to arrive at a measure of the likelihood that a pollutant came, or did not come, from a particular source.6

The chemical fingerprinting process is well known to chemists and those working in technical fields, but its acceptance by courts as reliable evidence is less developed.

---

5 The so-called “Administrative Daubert” standard is a relatively recent movement with growing momentum. For an overview of the argument for greater technical fidelity in the administrative context, see Alan C. Raul and Julie Z. Dwyer, *Regulatory Daubert: A proposal to enhance judicial review of agency science by incorporating Daubert principles into administrative law*. 66 L. Contemporary Problems 7-44 (2003).

6 As later sections will address, “chemical fingerprinting” refers generally to a class of analytical methods that can be used to generate data suitable for matching against known standards in the same way that traditional fingerprint data is used to identify a person by matching the print against those in a database. As an example of how chemical fingerprinting can be used, see Scout A. Stout, *et al.*, *The Role of Chemical Fingerprinting in Assessing the Impact of a Crude Oil Spill Following Hurricane Katrina*. 18 Env’tl. Claims J. 169-84 (2006).
• For example, see Scott A. Stout, et al., Use of Chemical Fingerprinting to Establish the Presence of Spilled Crude Oil in a Residential Area Following Hurricane Katrina, St. Bernard Parish, Louisiana, 41 Environ. Sci. Technol., 7242-51 (2007).

• See Litigation Environment for Drilling and Hydraulic Fracturing, 43 Envtl. L. Rep. News & analysis 10221 (March, 2013) (summarizing current issues in oil and natural gas litigation, including evidentiary issues arising from attempts to identify sources of contamination).

C. At the most basic level, chemical fingerprinting began as a method of determining what chemicals or contaminants existed in a complex sample matrix. Its utility for that purpose has extended to a variety of industries and chemical analytes.


D. Environmental Forensics is an entire field unto itself, including many kinds of techniques and investigatory methods designed to provide information about the state of the environment and those external stimuli that affect it.

Entire journals exist to publish the primary literature in the field of environmental forensics.

• For example, see
  o Environmental Forensics, published by Taylor & Francis.
E. Many of the most commonly used chemical fingerprinting techniques are special applications of normal chemical methods.


F. Using the data generated from environmental forensic techniques to determine the source of a contaminant or isolate the source of a chemical compound requires using statistical techniques to arrive at a likelihood, or probability, that the forensic fingerprint of the sample matches that of a known standard. In other words, most environmental forensic techniques can allow lawyers to definitively rule out a particular source of contamination, but they cannot affirmatively prove the source of contamination beyond all doubt.

---

\(^7\) Mass spectrometry is an analytical chemical method for determination of the chemical mass of a chemical compound. When coupled with other analytical techniques, especially various chromatographic methods, mass spectrometry is among the most powerful tools for chemical analytics. Its applications include determination of chemical mass and isotopic characterization of various elements. For a comprehensive review of the general applications of mass spectrometry in environmental science, see Susan D. Richardson, *Mass Spectrometry in Environmental Sciences*, 101 Chem. Rev. 211-54 (2001).

\(^8\) Stable isotope analysis (SIA, in the chemical literature), described in more detail later is a general term for the application of several analytical chemical methods to determine the isotopic composition of a sample, which is then compared against the isotope profile of a known standard or other reference sample.

\(^9\) Radioisotope analysis is a mature analytical technique dating back to the mid-twentieth century. For example, many readers will be familiar with the use of Carbon-14 dating techniques. This method is generally most appropriate for samples that are either very new or very old. Radioisotope analysis is a powerful tool, but finds more limited utility in environmental chemical fingerprinting applications. For an overview of the development of radioisotope use, see Alfred B. Garrett, *Carbon-14 Dating: Willard F. Libby*, 40 J. Chem. Ed. 76 (1963).
IV. Stable Isotope Analysis as a Tool in Fracking-Related Litigation

A. Stable Isotope Analysis is based on the differing atomic mass of certain elements on the periodic table and the ratio in which elements with differing masses are found in samples.

B. Isotopes are atoms of the same chemical element with differing atomic masses. Isotopes occur when certain atoms of an element have more neutrons in their nucleus than other atoms of the same element. For example, some of the most common isotope pairs\(^\text{10}\) utilized in stable isotope analysis include:

- Carbon – \(^{12}\)C and \(^{13}\)C
- Hydrogen – \(^{1}\)H and \(^{2}\)H
- Oxygen – \(^{16}\)O, \(^{17}\)O, and \(^{18}\)O
- Nitrogen – \(^{14}\)N and \(^{15}\)N

Most carbon atoms, for example, have six protons and six neutrons in their nucleus.\(^\text{11}\) That gives a carbon atom an atomic mass of twelve, equal to the number of protons plus the number of neutrons. However, some carbon atoms have six protons and seven neutrons. These carbon atoms have an atomic mass of thirteen, six plus seven.

C. Chemical manufacturers often produce compounds in discrete lots. The prevalence of specific chemical isotopes in these lots can distinguish one lot of a chemical from another lot. For example, chlorine has two predominant natural isotopes, \(^{35}\)Cl and \(^{37}\)Cl. In a truly random sample, the naturally-occurring ratio of \(^{35}\)Cl to \(^{37}\)Cl is very nearly 3:1.

Suppose that a case involves determining the probable source of a chlorine-containing compound present in the groundwater under a parcel of property. Using stable isotope analysis, an investigator would likely begin by determining the \(^{35}\)Cl to \(^{37}\)Cl ratio in the groundwater. Next, the investigator would seek to

\(^\text{10}\) Many elements have numerous isotopes, many of which are unstable and therefore cannot be utilized for stable isotope analysis.

\(^\text{11}\) Two important numbers accompany every element, its atomic number and its atomic mass. The atomic number of the element is the number of protons in the nucleus of the element. The number of protons in the nucleus determines the identity of the element. For example, every carbon atom has six protons. If an atom has more or less than six protons, it is no longer a carbon atom. The atomic mass of the atom, however, can differ depending on how many neutrons are in the nucleus of the atom. Continuing with the carbon illustration, the most common isotope of carbon has six neutrons in the nucleus. Adding together the number of protons (6) and the number of neutrons (6) gives an atomic mass of twelve (12). The atomic mass can differ depending on how many neutrons exist in the nucleus. Differing atomic mass values are referred to in the chemical literature as isotopes of the element.
determine the $^{35}\text{Cl}$ to $^{37}\text{Cl}$ ratio in the materials used by those operators alleged to have contributed to the contamination. A practitioner trained in the use of stable isotope analysis would then apply the appropriate statistical methods to determine the likelihood that each operator’s materials contributed to the alleged contamination.

V. Stable Isotope Analysis in the Courts

A. Stable isotope analysis is a well-known tool for chemical researchers. It has enjoyed widespread utility in chemical laboratories for decades, but its application as an investigative technique is more recent.


B. More recent cases have recognized stable isotope analysis as a mainstream analytical technique and accepted environmental forensic evidence based on stable isotope analysis as definitive evidence.


C. Lawyers using stable isotope analysis must be aware of the evidentiary issues associated with use of the method.

- The United States EPA recognizes the utility of stable isotope analysis, and says that “[s]table isotope analysis can be used in ecological studies to trace chemical movement through the environment.” (https://www.epa.gov/eco-research/stable-isotope-mixing-models-publications, last accessed, April 2, 2017).

- However, unlike many other analytical methods commonly encountered in environmental litigation, stable isotope analysis does not have a standard EPA-approved method.

---

12 Chloride stable isotope ratio analysis has applicability in a wide cross section of fields. As an example of how chloride stable isotope ratio analysis is performed and the way it could be utilized in an environmental forensic context, see Austin Long, et al., High-precision measurement of chlorine stable isotope ratios. 57 Geochemia et Geosmochimica Acta 2907-12 (1993).
• This increases the importance of the expert witness qualifying process under *Daubert*\(^{13}\).

• Rules of Evidence may differ among the states, but in the federal system, Rule 702 is the key.

• A witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if:
  
  o the expert’s scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue;
  
  o the testimony is based on sufficient facts or data;
  
  o the testimony is the product of reliable principles and methods; and
  
  o the expert has reliably applied the principles and methods to the facts of the case.

• In general, expert witness testimony advancing a conclusion based on stable isotope analysis is given the same standing as other witness testimony. Courts generally hold that once the expert witness is admitted as an expert, it is for the trier of fact to determine what weight to give to the stable isotope analysis.
  
  o *See City of Pomona v. SQM North America Corp.*, 750 F.3d 1036 (9\(^{th}\) Cir. 2014) (holding that the value of stable isotope analysis was to be determined by the trier of fact and “not by judicial fiat”).