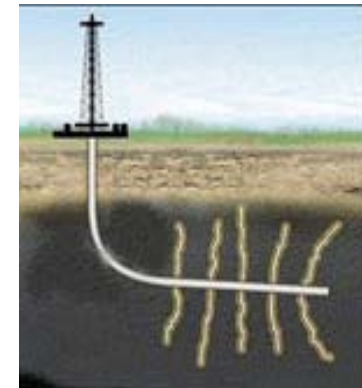


The Health Effects and Other Hazards of Hydrofracking



Presented by

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About this Presentation

- Precautionary Principle
- A little toxicology
- Chemicals used in hydrofracking
 - Products
 - Individual ingredients
- What comes back out of the ground
- Air contaminants and spills
- Next steps—what you can do



Precautionary Principle

- The **precautionary principle** is a moral and political principle which states that if an action or policy might cause severe or irreversible harm to the public or to the environment, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action.
 - **Do no harm**
 - **Prove scientifically that what you are doing is not harmful**
 - **Law in the EU**

Basic Toxicology

- Routes of entry of a hazardous material
 - Inhalation – breathing in
 - Ingestion – swallowing
 - Absorption through the skin or eyes
 - Injection – rarely happens
- Many hazardous materials can cause injury by any or all of the above routes of entry.
- The dose makes the poison *Paracelsus* But.....

Effects on living systems I

- Respiratory system

- Most likely
- Irritation, headache, pulmonary edema, asthma, systemic poisoning, degenerative diseases



- Gastrointestinal tract

- Contaminated water
- Low level effects
- Systemic effects involving many organs
- Degenerative conditions



Effects on living systems II



- Eyes and Skin

- Irritation, drying out, defatting, inflammation, burns

ACUTE TOXICITY

Single short exposure

Effects usually appear quickly

Effects often reversible

CHRONIC TOXICITY

Repeated exposure

Effects usually delayed

Usually irreversible

Effects on living systems II

- Factors influencing susceptibility to the effects of hazardous materials and agents
 - Age
 - Nutritional habits
 - Physical condition
 - Medical condition
 - Drinking and smoking
 - Sensitization
 - Pregnancy



- Duration of Exposure
- Rate of Exposure

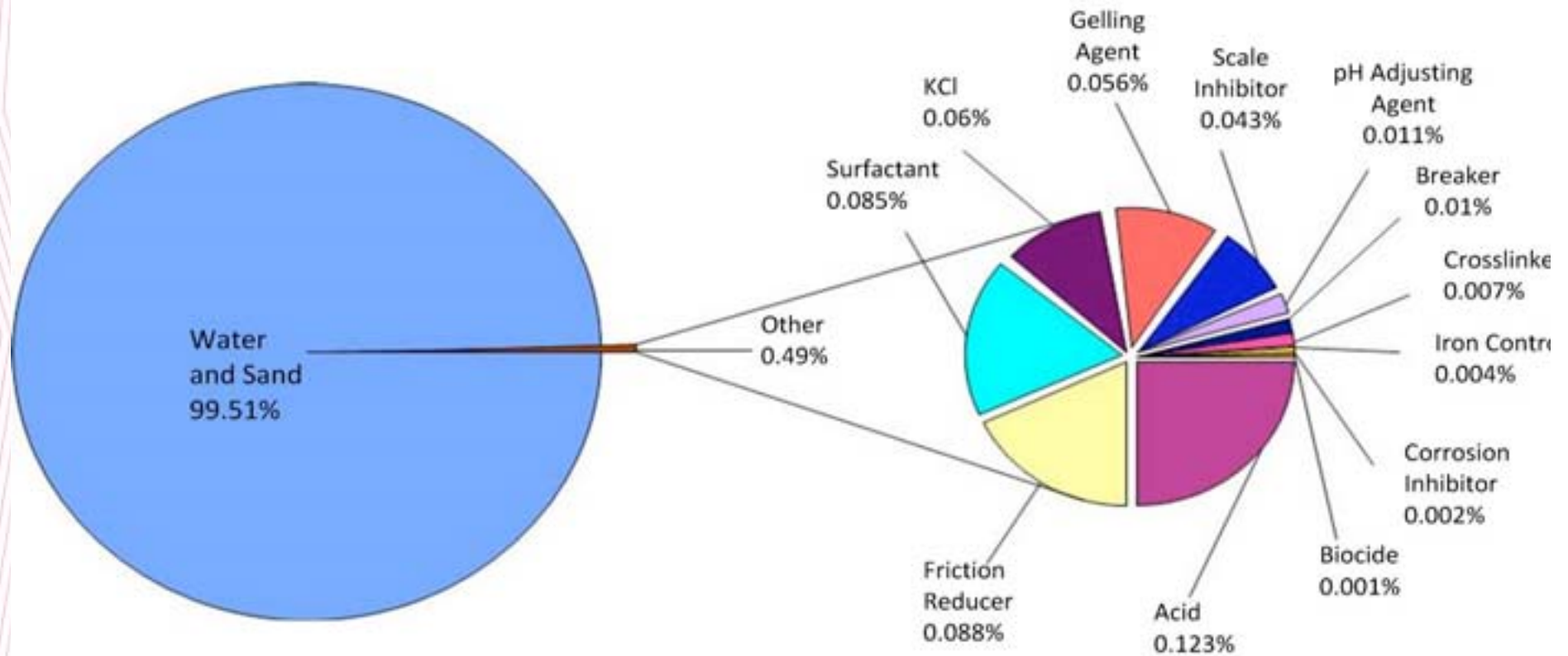
Products Used in Fracking I

- NY State dSGEIS lists 207 products; 48 have only a partial disclosure of ingredients
- TEDX lists 944 products used in fracking fluids nationally (5/10)
- Only a few products are used in any one fracking operation



Green Fracking Products?

Products Used in Fracking II



MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES: A PRIMER, US DOE, April 2009

Products Used in Fracking III

- The name rarely, if ever, says it all:
 - Alpha 125
 - BA-40L
 - Clay Master 5C
 - Ferrotrol 300L
 - OptiKleen-WF
 - PLURADYNE TDA 6
 - Scalecheck SPC-2
 - WFR-C



Products Used in Fracking IV

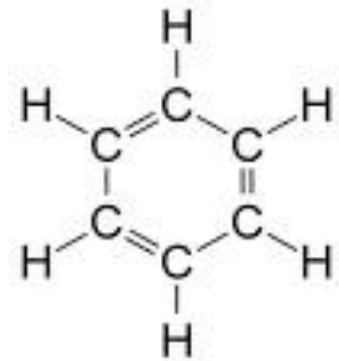
- Less than 1% of fracking fluid is “chemistry”
 - 0.5 to 0.75 percent is common
- If 1 million gallons is used in one frack, “chemistry” is 5,000 to 7,500 gallons of the materials used
- Many categories of products that are fracking fluid additives:
 - Proppants, acids, breakers, biocides, clay stabilizers, corrosion inhibitors, crosslinkers, friction reducers, gelling agents, iron control agent scale inhibitors and surfactants dSGEIS 9/30/2009, Table 5-5, p. 5-41 to 4
- One or several chemicals in each additive product

Chemicals Used in Fracking

- dSGEIS lists 257 distinct chemical substances that have the potential to be used in New York State dSGEIS 9/30/2009, Table 5-6
- TEDX lists about 632 distinct chemicals used in fracking fluids nationally TEDX Analysis of Chemicals Used in Fracturing 2-16-09
Natural Gas Operations from a Public Health Perspective, Colborn, *et al.*, 9-04-10
- PA DEP lists ~ 80 chemicals used in fracking
- “Compound-specific toxicity data are very limited for many chemical additives to fracturing fluids....”
dSGEIS 9/30/2009, p. 5-52
- dSGEIS groups chemicals into categories based on chemical structure or function and reviews the associated hazards of the chemicals by group; reviewed by NYSDOH—generic and cursory.
dSGEIS 9/30/2009, Table 5-7, pp. 5-61 to 5-65

Examples of Fracking Chemicals I

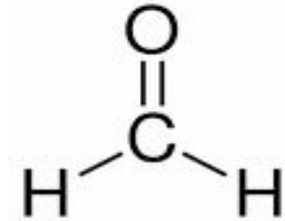
- Benzene and other aromatic hydrocarbons (BTEX)
 - Gasoline, petroleum distillates (Stoddard Solvent), Diesel fuel, polyaromatic hydrocarbons (PHAs)
 - Naturally occurring in produced water
 - Diesel has been used in fracking mixtures
 - High concentrations in Diesel exhaust, especially PHAs in particulate matter; environmental toxins
 - Known carcinogens (leukemia), damage to liver, central nervous system (narcotic effects) and other organs, damage to fetus (teratogens), cause genetic changes (mutagens), defat skin, irritants



Examples of Fracking Chemicals II

- Formaldehyde

- Used in a variety of fracking products
- A gas, used in aqueous solution
- Used in low concentration, but very toxic and dangerous even at these low concentrations
 - Has own OSHA standard; 0.5 ppm action level
- Known carcinogen, severe irritant (eyes, skin, lungs), systemic poison, severe sensitizer, biocide

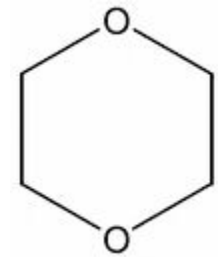


- Ingestion of one ounce of standard 37% solution is known to have caused death

Examples of Fracking Chemicals III

- 1,4-Dioxane

- Used in surfactants and other products
- Causes damage to the central nervous system, liver and kidneys; toxic, irritant
- Probable carcinogen



- Hydrochloric acid, HCl (muriatic acid)

- Used in large quantities in fracking fluids
- Strong acid; severely corrosive, strong irritant to eyes, skin, lungs



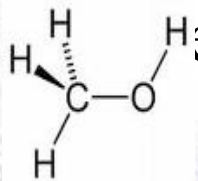
Examples of Fracking Chemicals IV

- Glutaraldehyde, a biocide
 - Very toxic; probably has no “no adverse effect level”; effects observed in mice at 0.02 ppb¹
 - Strong mutagen (damages chromosomes)
 - Severe irritant to eyes, skin, lungs; sensitizer



¹Chronic Toxicity Summary – Glutaraldehyde, http://oehha.ca.gov/air/chronic_rels/pdf/111308.pdf

- Methanol, methyl alcohol; used in many products
 - Highly toxic; 1-2 mg/kg. is lethal; causes blindness at even lower doses



Methanol Poisoning Overview, <http://www.antizol.com/mpoisono.htm>



Examples of Fracking Chemicals V

- 2-Butoxyethanol
 - Used in a wide variety of products; TEDX lists 16 (Windex)
 - Readily absorbed by skin/inhalation
 - Irritant, central nervous system effects, may damage liver, kidneys and lungs; suspect carcinogen¹
 - A known endocrine disruptor; effects noted at 0.02 mg/m³(2)

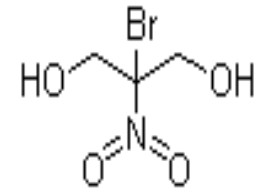


¹TOXICOLOGICAL PROFILE FOR 2-BUTOXYETHANOL AND 2-BUTOXYETHANOL ACETATE, ATSDR, August, 1998
<http://www.atsdr.cdc.gov/toxprofiles/tp118.pdf>

²Glycol Ethers, EPA Air Toxics Web Site, <http://www.epa.gov/ttn/atw/hlthef/glycolet.html>

Examples of Fracking Chemicals VI

- Bromine-based biocides



- Widely used in a number of products

- 2,2-dibromo-3-nitrilopropionamide (DBNPA)
- 2-bromo-3-nitrilopropionamide (BNPA)
- 2-bromo-2-nitro-1,3-propanediol (Bronopol, BNDP)



- Toxic, irritant, severely damaging to the eyes
- Severely toxic to aquatic organisms (fish)
- BNDP is a suspect carcinogen as it breaks down to form formaldehyde and nitrosamines in animals

<http://www.preventcancer.com/consumers/cosmetics/phthalates.htm>

<http://en.wikipedia.org/wiki/Bronopol>

And on and on.....

- Acrylamide—known human carcinogen
- Ammonium persulfate—strong oxidizer; skin sensitizer
- Ethylene glycol—toxic; multiple organ failure
- Formamide—reproductive hazard; embryotoxic in human
- Octylphenol and nonylphenol—degradation products of commonly used surfactants that are estrogen mimickers
- Propargyl alcohol—very toxic to multiple organs
- Tetramethyammonium chloride—a toxic biocide
- And many things that are unknown.....

What comes back out of the ground I

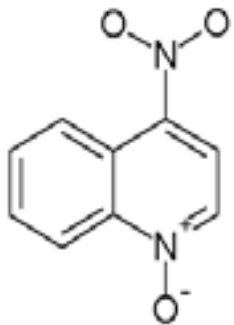
- Flowback fluids and produced fluids
 - “...between 9 and 35 percent of the fracking fluid pumped.” from Northern PA wells dSGEIS 9/30/2009, p. 5-97
 - Hundreds of thousands to millions of gallons per well
 - Held on site in ponds/pits or temporary storage tanks; treated at specialized waste water treatment plants
- “Parameters” detected in PA and WV wells include
 - Dissolved solids (chlorides, sulfates, calcium)
 - Most of this would be called “brine”, especially from produced fluids
 - Metals (calcium, magnesium, barium, strontium)

What comes back out of the ground II

- “Parameters” detected in PA and WV wells include (cont.): Draft dSGEIS 9/30/2009, p. 5-100 to 5-101
 - Suspended solids
 - Mineral scales (calcium carbonate, barium sulfate)
 - Friction reducers, iron solids (oxide and sulfides), dispersed clay fines, colloids and silts
 - Acid gases (carbon dioxide, hydrogen sulfide)
- Specific substances include: Tables 5-8 and 5-9, Draft dSGEIS, pp. 5-101 and following
 - BTEX—friction reducer, probably naturally occurring hydrocarbons in the shale;
 - Trihalomethanes—not in fracking fluids initially

What comes back out of the ground III

- Specific substances include (cont.):
 - Heavy metals—arsenic, barium (dissolved), cadmium, chromium, cobalt, lead, molybdenum, nickel, selenium, silver, strontium, thallium; some from fracking chemicals, but most from natural sources
 - 4-Nitroquinoline-1-oxide—found in flowback water but probably not in fracking fluids; potent mutagen and carcinogen; reproductive and developmental toxin; used to induce cancer in animals
 - Causes biological damage in parts per billion



What comes back out of the ground IV

- And last but not least.... **NORM**
 - Marcellus Fm. is high in **Naturally Occurring Radioactive Materials**—
identified in drilling logs by a spike in gamma rays
 - Uranium, radium-226, radium-228, radon “daughters”
 - The level of radioactivity in flowback water is many times higher than allowable for discharge to the environment Appendix 13, NYS Marcellus Radiological Data From Production Brine
 - “....may need regulatory oversight to ensure adequate protection of workers, the general public, and the environment.” Draft SGEIS 9/30/2009, Page 6-130 to 6-131



What comes back out of the ground V

- NORM (cont.)

- “...may be subject to discharge limitations specified in Part 380.” Draft SGEIS 9/30/2009, Page 7-102

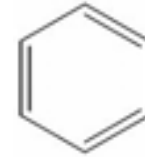


- “.....any discharge of effluents into the environment will need to be tested for NORM concentrations prior to discharge.” Draft SGEIS 9/30/2009, Page 7-103

- The question of the impact that all of these contaminants from flowback water might have on drinking water sources, if any, remains to be seen.

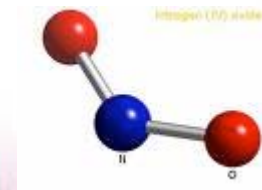
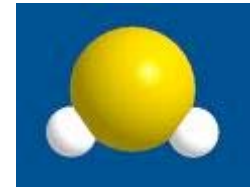
Air Contaminants I

- BTEX, along with other VOCs
 - Stationary and truck Diesel engines, flaring, venting, produced water storage, dehydration of natural gas; carcinogens
- Dust—ubiquitous problem, especially in summer
 - Dirt moving, vehicle traffic; hay fever, allergies; reduced visibility
- Natural gas—methane from venting, flaring, leaks
 - Severe greenhouse gas
 - Carries BTEX, other hazardous components of raw gas
- Carbon monoxide—engine exhausts, flaring; toxic



Air Contaminants II

- Hydrogen sulfide—occurs in formations with lots of pyrite, like the Marcellus
 - May come up with gas, acidic flowback water; very toxic; rotten egg smell
 - Probably a low risk in the Marcellus
- Nitrogen oxides (NO_x)--criteria pollutant regulated by EPA
 - Combustion of fossil fuels; Diesel engines, flaring operation
 - Reacts with VOCs to form ozone; makes reddish haze
 - Health impacts include respiratory problems, heart conditions and lung damage



Air Contaminants III

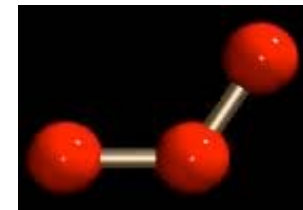
- Ozone—forms in “smog” by photochemical reactions
 - Forms in air pollution events from VOCs and NO_x
 - A highly reactive gas that causes respiratory problems and asthma; can have adverse health effects in parts per billion¹
 - The EPA proposes to reduce the 8-hour “primary” standard, designed to protect public health, to 0.060-0.070 parts per million²
 - Ozone can cause damage to plants and subsequent economic losses³

¹<http://www.epa.gov/o3healthtraining/population.html>

²<http://www.epa.gov/air/ozonepollution/pdfs/fs20100106std.pdf>

³<http://www.aces.edu/pubs/docs/A/ANR-0940/ANR-0940.pdf>

³<http://www.ars.usda.gov/Main/docs.htm?docid=12462>



Air Contaminants IV

- Particulate matter (PM)—small particles formed from burning fossil fuels; Diesel engines, flaring
 - May cause respiratory problems, cancer (PAHs)
- Sulfur dioxide—formed when fuels containing sulfur are burned; Diesel engines and flaring of natural gas
 - An EPA criteria air pollutant
 - A principal contributor to acid rain; damage to ecosystems, buildings
- Air contaminants are perhaps the most serious public health problem and overall hazard to the environment.



Spills

- An unintended release of a material
 - Can be a solid, liquid or gas
 - Usually thought of as occurring to soil or water and having adverse
 - Spills happen
 - Drilling site incidents will probably not affect the public but streams and lakes could be affected
 - Think overturned trucks
 - DEC/DOT and local haz mat teams respond to spills



Next Steps

- What you can do
 - Educate yourself on the issues involved
 - If you are a land owner with a lease or a concerned citizen do whatever you can to make gas drilling as environmentally friendly as possible
 - Address your concerns to the DEP
 - Visit and write your elected officials
 - Write letters to your local newspapers
 - Form coalitions to protect your environment
 - Reduce your energy consumption—Marcellus Challenge <http://sustainabletompkins.org/programs/marcellus-challenge/>