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ANALYSIS OF CHEMICALS USED IN NATURAL GAS PRODUCTION: COLORADO

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Introduction

This project was designed to explore the health effects of the products and chemicals used in operations to produce natural gas in Colorado. It provides a glimpse at the pattern(s) of possible health hazards for those living in regions where gas development is taking place. The names of the products and chemicals were entered in an EXCEL spreadsheet for easy sorting and searching. Health effects for chemicals were researched and fell into 14 categories based on standard use in government toxicological literature. We make no claim that this list is complete.

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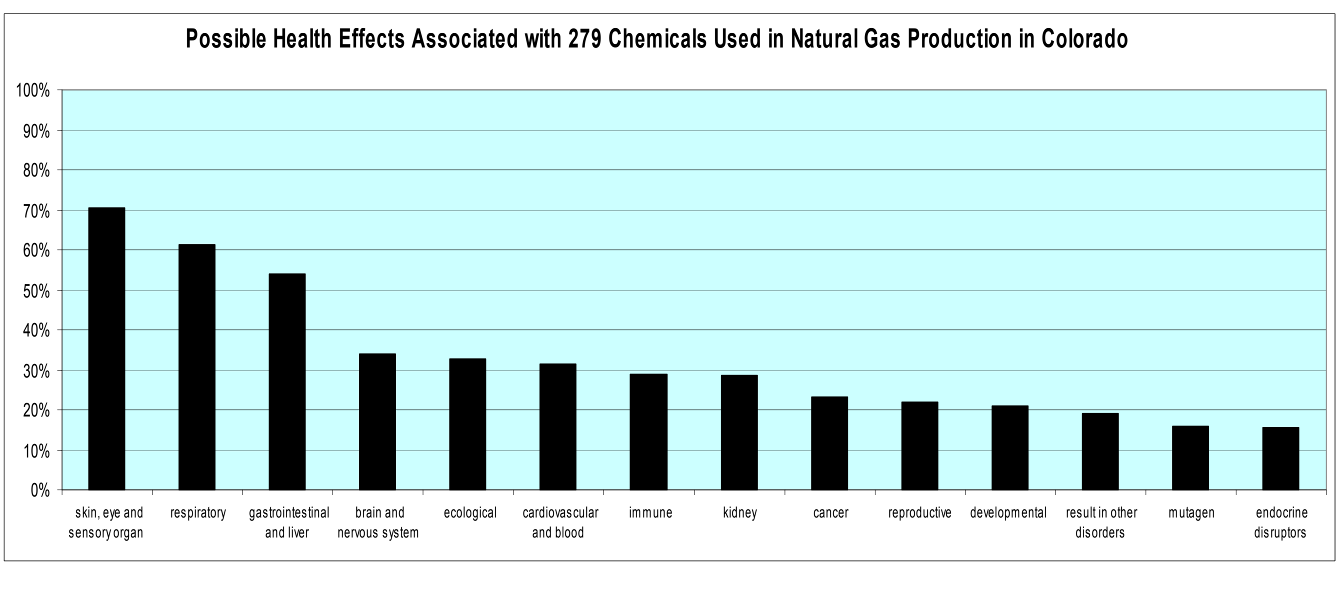
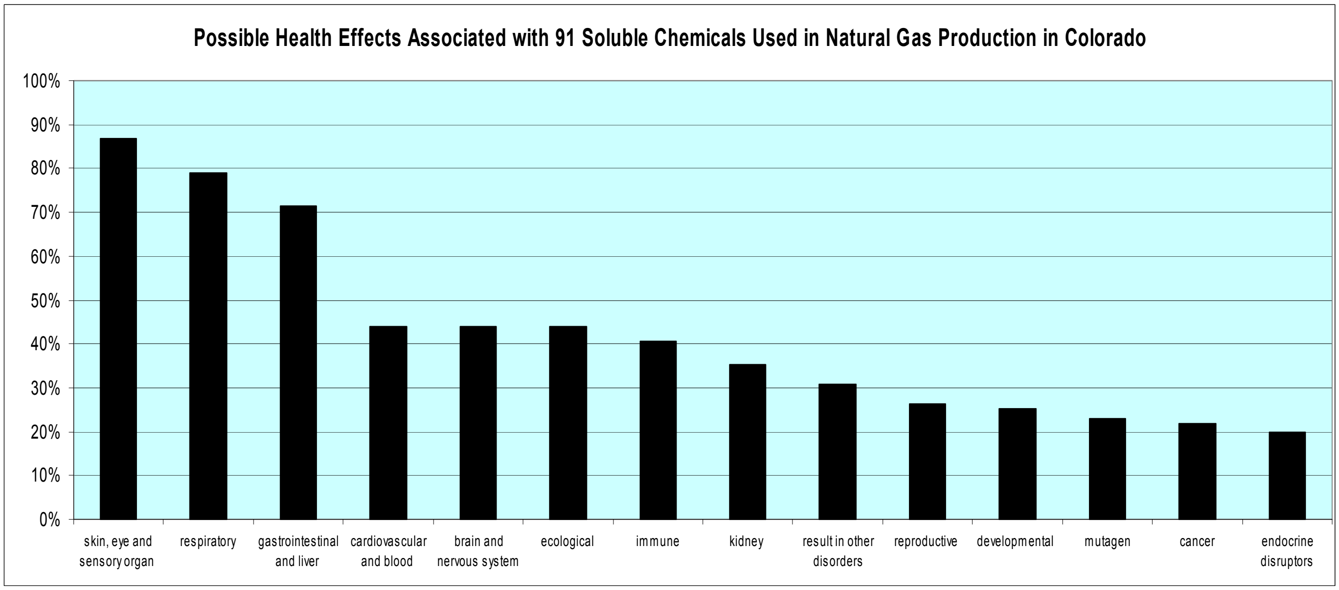
1. The 211 products contain at least 279 chemicals.

2. Ninety-three percent of the products have one or more adverse health effects. Of these, 19% have one to three possible health effects, and 81% have between four and fourteen possible health effects. Twenty-five products have 14 adverse health effects.

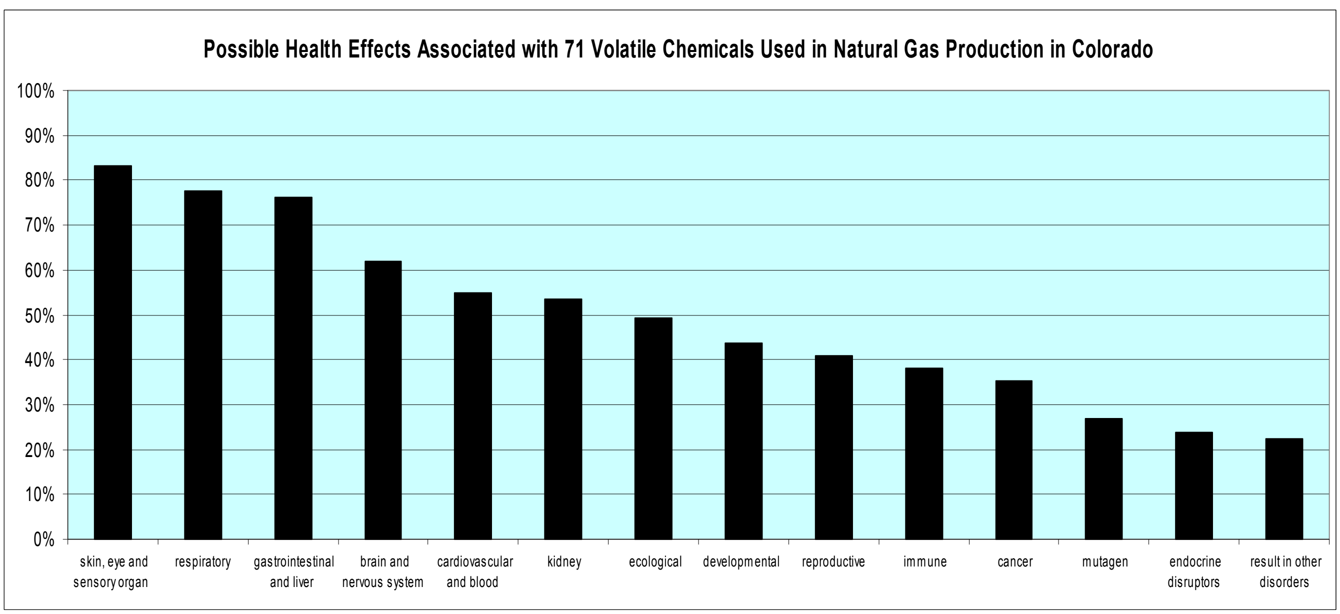
3. Upon plotting the percent of chemicals in each health category, a pattern emerged of the possible health effects for the 279 chemicals. The four categories with the highest exposure risk are (1) eyes, skin, and sensory organs; (2) respiratory system; (3) gastrointestinal tract and liver; and (4) brain and nervous system.



4. Ninety-one chemicals were water soluble. The four categories with the highest exposure risk are (1) eyes, skin, and other sensory organs: (2) respiratory system; (3) gastrointestinal tract and liver; and (4) cardiovascular and blood.



5. Seventy-one chemicals were volatile. The four categories with the highest exposure risk are (1) eyes, skin, and other sensory organs; (2) respiratory system; (3) gastrointestinal tract and liver; and (4) the brain and nervous system.



6. Several reasons led to the lack of data about the health effects of some of the products and chemicals on the spread sheet:

(a) Some products list no ingredients.

(b) Some products provide only a general description of the content, such as “plasticizer”, “polymer” etc.

(c) Some products list some or all of the ingredients as “proprietary”.
(d) No health effect data were found for a particular chemical or product.

7. Much of the information about the composition of the products on the list comes from a Material Safety Data Sheet (MSDS). Ingredients on MSDSs are sometimes labeled as “proprietary”, or “no hazardous ingredients” even when there are significant health effects listed on the MSDS.

8. Some of the citations used to establish the health effects of the chemicals on this list are old, dating back to the 1970’s and 80’s. In several cases data were derived from abstracts, not the full report or manuscript. In other cases, citations were taken from toxic chemical databases, such as TOXNET, Chem ID, etc. Many reports submitted to the US Environmental Protection Agency by the manufacturer to register a chemical are not accessible. In some cases it is impossible to track down any health effect for a chemical, especially when the manufacturer provides no Chemical Abstracts Service (CAS) number.

9. No health effects were found for 67 of the chemicals on the list. Of these, only 15 had been assigned a CAS number which facilitates searching the literature. We found no health related literature for these chemicals. It was impossible to determine the safety of the other 52 chemicals either because they were listed as mixtures, proprietary, or unspecified (12), or had chemical names that were so general that the specific chemical could not be identified (40).

10. From early on, as new products were added to the list, the sequence of the categories in the pattern of the percentages has shifted only slightly. Looking at data from other states, the pattern also holds. It is expected that slight changes in sequence from one position to another will continue to occur as more products and chemicals are entered into the database.

For Further Consideration

MSDSs are designed to inform those who handle, ship, and use the product(s) about the products’ physical and chemical characteristics, and its direct/immediate health effects to prevent injury. The sheets are also designed to inform emergency response crews in case of accidents or spills. The data in the MSDSs do not generally take into consideration the health impacts resulting from chronic or long-term, continuous, and/or intermittent exposure. Many products that have MSDSs have not gone through a rigorous and extensive scientific peer-review process that would permit conclusions to be drawn about "safe" and/or "hazardous" exposure levels.

The use of respirators, goggles and gloves is advised on many of the MSDSs for products on this list. This indicates serious, acute toxicity problems that are not being addressed in the recovery process when the chemicals come back to the surface. It also raises concern over possible hazards posed to those living in regions where gas production is taking place.

The product manufacturers are responsible for the MSDSs, which are based on a form provided by the Occupational Safety Health Administration (OSHA). OSHA provides no review or approval of the sheets, which are often sketchy and may provide health effects information for only one or two chemicals in a product. In many cases the chemicals listed equal less than 100% of the product. In the case of mixtures, the health effects warnings are often not chemical-specific.

Some of the chemicals on this list have been tested for lethality and acute toxicity based on short-term contact looking for possible ecological damage. The tests are done to find out how long it would take to kill 50% of the organisms within a predetermined time limit, such as 24, 48, or 96 hours. The results of these tests are presented as the lethal concentration (LC50) or lethal dose (LD50). The tests are used for precautionary label notations in order to reduce immediate harmful effects on "non-target" organisms such as invertebrates, algae, beneficial insects, fish, etc. in the food web. These tests are not intended to provide information about long-term exposure effects and they do not exclude the fact that other health effects can occur.

Background

Prior to use, these products must be shipped to and stored somewhere before being transported to the well site. They pose a hazard on highways, roads, and rail systems, as well as to communities near the storage facilities.

During the well-drilling stage, underground water, drilling muds, and cuttings of rock and debris from the well bore surface and are deposited in production pits on the well pad. After development ceases on a pad and the well(s) goes into production, the residues in the production pits are often bulldozed over. It is impossible to predict how long the buried chemicals will remain in place. Highly persistent and mobile chemicals could migrate from these pits into underground water resources, or gradually surface over time.

Fracturing, frac'ing, and stimulation are terms used to describe a process commonly used to facilitate the release of the gas and improve production. In this process approximately a million gallons of fluid, under extremely high pressure, are injected underground, and, with explosives, create mini-earthquakes that open up fractures in the strata being mined. The gas industry claims that 70% of the material it injects underground is retrieved. While the fate of the remaining 30% is unknown, the recovered materials are often placed in holding pits on the surface and allowed to evaporate. This activity results in highly toxic chemicals being released in the air. New technology is now available to re-inject the recovered frac'ing fluid either on site, or pipe it to a central re-injection well. Where the fluids sit in open pits, their condensed residuals are taken off-site and dealt with in two ways: (1) they can be re-injected in the ground, or (2) they can be "land farmed" in which they are incorporated into the soil through disking. Here, toxic metals and silica fines would continually build up in the disked soils and could be mobilized on dust particles. At some locations, because of regional differences in geology and technology, 100% of the injected frac'ing fluids may remain underground.

For the life of a gas well in most regions, water may be stripped from the gas before it enters the delivery pipeline. Each gas well has a condensate water tank where this contaminated water is stored. In some instances the condensate water is re-injected on site or piped to a central re-injection well. In other instances, water levels are monitored in the condensate tanks and the water trucked to large open-pit, waste facilities where the water and volatile chemicals escape into the air. This will continue until the well stops producing gas, which could be as long as 20 to 25 years.

Discussion.

The physical characteristics of a chemical can contribute to its becoming a chemical of concern, as well as its application or use. For example, crystalline silica is reported in 33 products on this list ranging from <1% to 30% of the total composition. It poses its hazard as a respirable dust that lodges permanently in the lungs and can cause silicosis, emphysema, obstructive airway diseases, and lymph node fibrosis. It is not captured in either the water-soluble or volatile pathways in this analysis. It poses a long-term, delayed health hazard similar to asbestos, but can rapidly turn into malignant lung cancer. It is reported in both drilling and fracturing products. Oftentimes, the cuttings captured in drill pad reserve pits are used to produce berms or as fill on the pad. Over time, silica in the drilling muds could become airborne as dust along with other toxic compounds. The MSDSs recommend the use of respirators and goggles when handling the silica-containing products when dust is formed.

The foamer and solvent, 2 butoxyethanol (2-BE), is reported in 6 products on the list ranging from 5 to 40% of the total composition. 2-BE is captured in both the water-soluble and volatile pathways in this analysis. It is highly soluble (miscible) in water, colorless, and odorless at low concentrations, and evaporates at room temperature. It has a number of unusual health impacts that would baffle physicians and veterinarians and also causes several kinds of rare cancers. If it were to penetrate a drinking water source, exposure could be through ingestion, inhalation, and the skin.

The products labeled as biocides on the list are extremely toxic and with good reason. Bacterial activity in well casings, pipes and joints can be highly corrosive, costly, and dangerous. Bacteria can also alter the chemical structure of polymers and make them useless. Nonetheless, when these products return to the surface either through deliberate retrieval processes, or accidentally, they pose a significant danger to workers and those living near the well and evaporation ponds. They can also sterilize the soil and inhibit normal bacterial and plant growth for many years.

Among the 93% of products on the list with adverse health effects, 41% contain chemicals that have the potential to disturb the endocrine system, expressed as problems of the thyroid, pancreas, and gonads to mention a few. Like many categories at lower risk of exposure, the effects may not become apparent until years after exposure. Health problems in other lower risk categories such as kidney, reproductive problems, and cancer may not be diagnosed until years later.

A number of chemicals on this list are toxic when encountered in high concentrations. Exposure route, such as ingestion, inhalation, or through the skin, can delay or shorten reaction time. The long term effects of the chemicals of this nature cannot be predicted. Because only a small percentage of the total composition of most of the products on this list is available, it is not possible to determine if the chemicals are harmless in their application. In addition, under the present system, there are not enough data to determine the safety of products that contain mixtures of relatively “benign” ingredients and unknown chemicals, when the actual percentage composition is not provided.

Cumulative exposure impacts cannot be addressed in this analysis. The EXCEL spreadsheet provides a hint of the combinations and permutations of mixtures possible and the possible aggregate exposure. Each drilling and fracturing incident is custom-designed depending on the geology, depth, and resource available. The chemicals and products used, and the amounts or volumes used can differ from well to well. In addition, the fluids or vehicles that make up the full composition of a product are frequently not provided and nowhere are there data accounting for the fluids that make up the million gallons of fracturing fluid. The only way to get a realistic picture of what is being introduced into watersheds, air, and soil is to keep complete records on each specific well site (state, county, township, section, etc.), the formulation of the products used at each stage of development and production and their weight and/or volume, the total volume injected underground and recovered, the depths at which material/mixtures were injected, the amount and composition of the recovered liquids, and their disposal method and location.