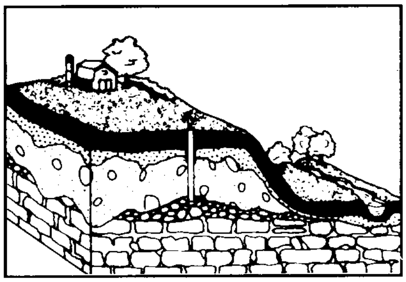

Soil Facts

Pollutants in Groundwater: Risk Assessment

Public officials and private citizens are concerned about the health risks from groundwater contamination. This concern has led to the enactment of laws to prevent groundwater contamination by regulating chemical use, storage, and transport. These laws require that the principal federal regulatory agencies limit human exposure to potentially dangerous chemicals. This fact sheet describes the process of assessing the potential risk of chemicals and discusses several of the key health-related groundwater contaminants.

Groundwater is the primary source of drinking water for 55 percent of all North Carolinians and for 97 percent of the state's rural residents. Until recently we assumed that a clean, fresh, abundant supply of groundwater would always be available, but increasing contamination incidents have heightened our awareness of its vulnerability.

North Carolina's groundwater is generally free of contamination. Only a small percentage of it requires treatment before the water can be used in the home. Naturally occurring conditions requiring treatment include excessive hardness and high concentrations of elements such as iron, manganese, and sodium. In addition to these naturally occurring conditions, however, there is also the threat of contamination from man-made chemicals. Major sources of these potential groundwater contaminants are underground storage tanks, chemical spills, landfills, abandoned dumps, and pesticide and fertilizer applications. Determining the danger of these possible contaminants involves a process called *risk assessment.*

What is Risk Assessment?

Risk is the probability of injury, disease, or death under specific circumstances. Everything we do has some degree of risk. The risks associated with some activities can be accurately predicted by examining precise data. The risks associated with other activities, including the exposure to various chemicals, cannot be readily assessed and quantified. Historical data on risks of chemical exposure may involve a single, very high exposure that has resulted in an immediately observable form of injury. Assessment of the risks of chemical exposures that do not cause immediately observable forms of injury or disease is far more complicated.

Some common questions about groundwater pollutants are:

- How toxic is the chemical?
- What are the chances that a certain chemical might contaminate groundwater at a specific location?
- How much, if any, of a specific chemical can be consumed without adverse health effects?
- How many people are likely to be affected and for what duration?

Risk assessment provides answers to these and similar questions by examining the following information:

Hazard identification determines the type of toxicity the chemical produces, such as cancer or birth defects.

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Dose-Response Assessment is a measure of the relationship between the dose (the amount of exposure) and the incidence of toxic effects.

Exposure Assessment quantifies the amount and duration of exposure to a chemical via all possible routes, such as by consuming contaminated water or food or inhaling polluted air.

Risk Characterization is an estimate of the potential incidence of any adverse health effects, such as acute poisoning or cancer in a population likely to be exposed to a given chemical.

Which Pollutants Are Toxic?

Any chemical can be toxic if the dose is high enough. Toxicity is considered *acute* if the effects are evident almost immediately after exposure to a chemical. Examples of acute health effects are nausea, lung irritation, skin rash, vomiting, dizziness, and even death. The concentrations of chemicals in groundwater, however, are seldom high enough to cause acute toxicity.

The typical range of concentrations of chemicals in contaminated groundwater is in micrograms per liter (μg/L), which is the same as parts per billion (ppb). At these concentrations, any effects on consumers of this water would be *chronic* in nature—those that may occur as a result of many years of exposure to the chemical. Examples of chronic health effects include cancer, birth defects, organ damage, nervous system disorders, and immune system damage. *There is no direct evidence linking groundwater contamination by pesticides to any chronic health effects.*

Risk assessment is used to help determine the dangers in the relationship between drinking contaminated groundwater and potential health problems. This risk is usually impossible to determine precisely. In risk assessment, scientists predict the *potential* for adverse effects of exposure to chemicals by using data from laboratory animal studies and, when available, studies of human exposures.

How Much Is Too Much?

In deciding what restrictions to place on the uses of chemicals, regulatory agencies assess the health risk associated with those uses. If the risk is judged too high, use of the chemical may be severely restricted or outlawed altogether. Uses are allowed under specified conditions only when the risk is judged acceptable. An example of an acceptable risk would be a 1 in 1,000,000 increase in the risk of developing cancer. The increase in cancer risk is weighed against the risk of getting cancer in your lifetime, which is roughly 3 in 10, or 300,000 in 1,000,000. A change of 1 against a background of 300,000 is so small a change in risk that government agencies are likely to consider it acceptable.

The 1974 Safe Drinking Water Act and its 1986 amendments require the U.S. Environmental Protection Agency (EPA) to set standards for contaminants in drinking water that may pose health risks. This amount, called the *reference dose (RfD)*, carries a very low risk of causing adverse health effects. To calculate the reference dose, you must know the maximum daily dose of a toxic substance that does not produce any observable adverse health affects. This *no-observable-adverse-effect-level (NOAEL)* dosage is divided by safety factors (SF), to obtain the reference dose:

$$\mathrm{RfD} = \frac{\mathrm{NOAEL}}{\mathrm{SF}}$$

The safety factor accounts for uncertainties in the quality of the data, the differences in toxicity to humans and to test animals, and the variations in sensitivities to a given toxic substance expected in the exposed populations. The regulatory agencies generally use safety factor values in the range from 10 to 1,000.

Several different types of numbers are available for determining drinking water contamination. The EPA standard for lifetime exposures in drinking water, the *maximum contaminant level (MCL)*, is the highest amount of a contaminant allowed in drinking water supplied by municipal water systems. (See Table 1.) Regulators use the reference dose to establish a maximum contaminant level for a contaminant, assuming that the exposure comes from drinking 2 liters of contaminated water per day for 70 years. The *maximum contaminant level goal (MCLG)* is a preliminary standard set but not enforced by the EPA. Maximum contaminant level goals are based entirely on health risk assessment, but maximum contaminant levels also take into consideration the feasibility and cost of analysis and treatment of the regulated contaminant. Although often less stringent than the corresponding maximum contaminant level , the maximum contaminant level goal is set to protect health. Finally, the Lifetime Health Advisory Level (LHAL) is offered by the EPA as a guidance number when maximum contaminamt levels are not available. (See Table 1.)

Studies of groundwater contamination by chemicals have demonstrated that the water in the vast majority of wells is safe to drink. The area of North Carolina most susceptible to groundwater contamination is the coastal plain, where groundwater is close to the surface, soils are very porous, and intensive agriculture is widespread. Surveys of wells in several of these counties have found several pesticides in a number of wells, but the concentrations have rarely been above health limits.

Uncertainties in Risk Assessment

Scientists and regulatory officials are painfully aware of the numerous uncertainties encountered at every stage of risk assessment. Sources of these uncertainties are

- deficiencies in toxicity and dose-response data
- deficiencies in data on the behavior of contaminants in soils and groundwater
- unknown interacting toxic effects resulting from exposure to multiple toxicants
- assumptions made in extrapolating from test animals to humans and from high to low doses
- variations in the magnitude of toxic effects expressed among and within different age groups of a population from exposure to a toxicant
- difficulties in estimating the duration and intensities of life-time exposures to various toxicants.

The safety factor (SF) used in estimating the reference dose, maximum contaminant level goal, and maximum contaminant level is intended to account for such factors and also for all other unknown or unmeasurable factors.

Given these uncertainties, an argument could easily be made that the regulatory policy must seek to avoid any risk. That argument, however, would be impractical. Applied consistently, such policies would ban automobiles, a safety measure most of us would not support despite the evidence that 1 in 5,000 will die this year in a car accident. A more responsible approach is one that asks us to determine what level of risk we are willing to tolerate given the considerable benefits that the risk-causing agent will provide. Regulatory agencies usually consider a lifetime risk of health effects of 1 in 1,000,000 to be acceptable for chemical exposure because it is small enough to be insignificant compared to other risks or because it is extremely difficult, if not impossible, to measure. Determining the "acceptable" risk level is fundamental to any risk management program.

Summary

Methods used to assess and manage the risks from consuming contaminated groundwater are based on scientific data and provide a rational basis for quantifying the hazards of groundwater contamination. Social, legal, economic, and political considerations are also involved in fashioning appropriate guidelines for preventing or minimizing groundwater contamination.

Table 1. Examples of Health Limits for Contaminants Found in Drinking Water

Contaminant	Product Name*	Use	Health Limit (µg/L or ppb)
Alachlor	Lasso	Herbicide	2[1]
Atrazine	AAtrex	Herbicide	3[1]
Aldicarb	Temik	Insecticide	7[1]
2,4-D	Weedone	Herbicide	70[1]
Cyanazine	Bladex	Herbicide	1[2]
Dicamba	Banvel	Herbicide	200[2]
Glyphosate	Roundup	Herbicide	700[1]
Metolachlor	Dual	Herbicide	100[2]
Metribuzin	Sencor	Herbicide	200[2]
Prometon	Pramitol	Herbicide	100[2]
Simazine	Princep	Herbicide	4[1]
Benzene	NA	Component of gasoline, solvent	5[1]
Carbon tetrachloride	NA	dry cleaning	5[1]
Toluene	NA	Component of gasoline, solvent	1,000[1]

Source: Drinking Water Regulations and Health Advisories. December 1993. Washington, D.C.: Office of Water, U.S. Environmental Protection Agency. Updated information is available by calling the Safe Drinking Water Hotline at 1-800-426-4791.

*Product names given are examples. Other products may contain these chemicals. NA is not applicable because many products contain these chemcials.

[1] Maximum Contaminant Levels

[2] Lifetime Health Advisory Levels.

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