SOUTH DAKOTA GROUND WATER QUALITY

What Is Ground Water Quality?

Ground water quality is judged by the amounts and types of materials that are present. Ground water is not pure H_2O; it contains a variety of dissolved substances including gases and *ions*. Ground water may also contain organic matter and suspended materials, such as silt. In contrast, distilled water is nearly pure H_2O, from which virtually all of the living organisms and dissolved and suspended substances have been removed.

What Are Some Water Quality Classifications?

The total dissolved solids (TDS) concentration in a water sample may be used to classify the water into one of four categories. Fresh water is defined by TDS concentrations ranging from 0 to 1,000 milligrams per liter (mg/L). Brackish water contains 1,000 to 10,000 mg/L TDS, saline water contains 10,000 to 100,000 mg/L TDS, and brine water contains more than 100,000 mg/L TDS.

What Is Good Ground Water Quality?

Generally, good quality water is water that is safe for its intended use (for example, human consumption, livestock, or irrigation). Most substances dissolved in water do not adversely affect the taste, smell, appearance, or the hardness of the ground water. However, a few, such as lead, arsenic, or nitrate, may be harmful to a person's health.

Listed in Table 1 are some common substances measured in water. Included for each are the recommended standards and, in a few cases, the enforceable drinking water standards for public water supplies. Also listed in Table 1 are examples of concentrations of these substances (average, maximum, and minimum) from ground water samples collected from the Big Sioux aquifer in eastern South Dakota. The Big Sioux aquifer water samples were collected from observation (monitoring) wells. Finally, the cause or impact of excessive concentrations are stated.

TABLE 1. General Water Quality Information

	EPA[1] Drinking Water Standards		Big Sioux Aquifer	
	Recommended	Enforceable		
SUBSTANCE	**mg/L**	**mg/L**	**mg/L**	**CAUSE/IMPACT**
TOTAL DISSOLVED SOLIDS	500		Avg. 673 Max. 3040 Min. 244	This refers to the total amount of dissolved materials; primarily calcium, magnesium, sulfate, chloride and sodium. The standard is based on taste, not health considerations.
HARDNESS (calculated)	180[2]		Avg. 515 Max. 1920 Min. 72	Hardness due to calcium and magnesium, and to a lesser extent iron and manganese, often reduces the effectiveness of soap and can cause incrustations in teapots, water heaters, etc.
SULFATE	250		Avg. 227 Max. 1720 Min. < 5	There is a taste effect at levels above 500 mg/L. Although levels above 600 mg/L initially have a laxative effect, tolerance usually develops fairly quickly.
CHLORIDE	250		Avg. 10 Max. 62 Min. < 1	Levels from 250-500 mg/L can cause an objectionable taste.
SODIUM	270[2]		Avg. 32 Max. 142 Min. 4	Levels above 500 mg/L when combined with chloride, produce a salty taste. Higher levels are associated with hypertension and heart disease.
POTASSIUM			Avg. 4.7 Max. 21.2 Min. > 0.1	Since there is normally a small range of values, high levels may indicate contamination from potash in commercial fertilizers.
NITRATE (as nitrogen)		10	Avg. 1.9 Max. 19.0 Min. < 0.1	High levels often indicate contamination from animal or human wastes or fertilizers. Levels above 10 mg/L may cause "blue baby" disease (methemoglobinemia) in infants under 12 months.
IRON	0.3		Avg. 0.7 Max. 4.6 Min.< 0.01	Levels above 0.3 mg/L may produce a taste effect and cause staining of plumbing fixtures.
MANGANESE	0.05		Avg. 0.7 Max. 5.0 Min.< 0.01	Levels above 0.2 mg/L may cause staining of plumbing fixtures, while levels above 0.5 mg/L may cause a taste effect.
FLUORIDE	2.4	4.0	Avg. 0.38 Max. 1.02 Min. 0.10	Public water supplies are fluoridated to a level of 1.2 mg/L to inhibit tooth decay. Levels above 2.0 can cause discoloration (mottling) of teeth. Levels above 4.0 cause skeletal damage.

[1] EPA - U.S. Environmental Protection Agency

[2] These standards, or limits for maximum concentrations, are recommended by the state of South Dakota rather than EPA.

Adapted from East Dakota Conservancy Sub-District (1984). Data are in mg/L (milligrams per liter).

Who Determines Water Quality Standards?

The United States Environmental Protection Agency (EPA) has established enforceable, as well as recommended, drinking water standards for humans and livestock in the United States. South Dakota has adopted these federal standards and has established more stringent standards in some instances. Most of these standards are based on health risk assessments.

How Is Ground Water Quality Measured?

To determine if water is acceptable for drinking, several measurements can be made. These measurements are used to evaluate the amount and types of substances present in the water.

First, the individual concentrations of some potentially harmful substances (like lead) or organic substances (like bacteria) are measured. Concentrations of nuisance substances (like iron) may also be determined. For example, if a water sample contains so much dissolved iron that the laundry turns orange, that water supply may not be an acceptable one to use! Treatment is available for water with excessive iron concentrations.

Secondly, the TDS concentration for all the substances may be determined. Lesser concentrations of TDS generally mean better water quality. For example, if a pinch of salt is dissolved in a glass of distilled water, it is not nearly as unpalatable as if a tablespoon of salt were dissolved in the same size glass of water.

Both of these types of measurements mentioned above (individual substances and TDS concentrations) may be used together to determine if a water supply is acceptable to drink. For example, if a water sample has a low TDS concentration, but the arsenic concentration exceeds EPA's enforceable limit, then that water is not safe to drink.

Does Ground Water Quality Vary Naturally?

Ground water quality can vary from place to place and through time. In any given area, the type of rock through which the ground water flows can be an important factor in determining water quality. For example, limestone dissolves relatively easily in ground water; that is how cave systems form (refer to the *Caves of South Dakota* fact sheet for more information). Limestone is made of calcium carbonate. The ground water that percolates through limestone acquires increased calcium and carbonate *ion* concentrations.

Water collected from different depths in an aquifer can exhibit differing quality. For example, nitrates tend to concentrate in the upper part of a surficial *unconfined aquifer,* whereas concentrations tend to be lower near the bottom.

How Does Human Activity Influence Water Quality?

In general, human activity degrades ground water quality. Ground water is used for personal consumption and other household uses, for industrial processes, and for irrigation. Accidental contamination may also impact ground water quality.

Contamination sources are classified as point sources or as nonpoint sources. **Point sources** of contamination include those sources for which the contamination can be traced to a specific location. For example, a pesticide spill or a leaky underground gasoline storage tank would be considered a point source of contamination. **Nonpoint sources** of contamination include such things as runoff collected through a maze of storm drains throughout a city, or fertilizer and pesticide applied to cropland. In nonpoint source pollution, it is impossible to identify a specific location where contamination may have been introduced into the runoff or into the ground water.

Can Ground Water Quality Be Improved?

Implementing a method to improve water quality depends on the nature of the problem. In a strict sense, a municipal drinking water supply is degraded when chlorine and fluorine are added to the water supply. However, the chlorine kills bacteria that are present and the fluorine are added to inhibit dental decay. It is generally perceived that adding these substances actually improves the quality of the water because it decreases the risk of some health problems.

Many innovative techniques are available to improve water quality using both natural methods and artificial treatment systems. In agriculture, certain types of plants may be used near creeks and rivers where ground water is discharging to the surface to help remove possible excess chemical nutrients (for example, fertilizers) in the ground water. In some situations (for example, excessive iron concentrations in ground water), filtration systems are used to remove the contaminants. One very expensive process for improving the quality of water polluted by petroleum is that of injecting gasoline-metabolizing bacteria and other nutrients into the subsurface. These specialized bacteria "eat" the gasoline, thereby cleaning up the ground and ground water.

Why Is Good Ground Water Quality Important?

Good quality water is important not only to sustain life, but also for its integral role in and value to society. In South Dakota, approximately 95 percent of the public drinking water supply is obtained from ground water (Tom Bradner, South Dakota Department of Environment and Natural Resources, Drinking Water Program Public Water Supply Data Base, personal communication, 1995). The world is increasingly dependent on good quality ground water for personal use, for industrial use, and for agricultural production. This resource is vital for maintaining and improving society.

Who Tests Ground Water Quality In South Dakota?

Public drinking water supply systems are responsible for having their water tested. Regular testing is required by state and federal law. The responsibility of testing the water in privately owned water wells lies with the well owner. Several laboratories in South Dakota can perform many types of analyses for a fee (see Table 2). For additional information, contact the South Dakota Department of Health, Laboratory Services, Health Laboratory, Pierre, South Dakota 57501; telephone 605-773-3368.

TABLE 2

Some South Dakota Laboratories

Energy Laboratories, Inc.
610 Farnwood Avenue
Rapid City, South Dakota 57701
Telephone: 605-342 -1225

Huntingdon Engineering
& Environmental, Inc
601 E. 48 St. N.
Sioux Falls, South Dakota 57104-0698
Telephone: 605-332-5371

Mid-Continent Testing Lab
2381 Plaza Drive
Rapid City, South Dakota 57701
Telephone: 605-348-0111

South Dakota Department of Health
Laboratory Services, Health Lab
Pierre, South Dakota 57501
Telephone 605-773-3368

Water Quality Laboratory
Rm. 204 Ag. Engineering Bldg.
South Dakota State University
Brookings, South Dakota 57007
Telephone: 605-688-5612 or 4910

Glossary

Aquifer - rock or sediment that is sufficiently permeable to conduct ground water and to yield economically significant quantities of water to wells and springs.
Ion - any atom or group of atoms that carry either a positive or negative charge.
Total dissolved solids - the total amount of all substances dissolved in water.
Unconfined aquifer - an aquifer in which the ground water has a water surface (water table) that is at atmospheric pressure and that is not overlain by an impermeable layer.

Glossary terms are adapted from the Bates, R.L., and Jackson, J.A., 1987, Glossary of Geology, American Geological Institute, Alexandria, Virginia.

References

East Dakota Conservancy Sub-District, 1984. The Big Sioux Aquifer Water Quality Study, Presentation of Data and Findings: Brookings, South Dakota, East Dakota Water Development District, second in a series, 15 p.
Hill, John W. 1988. Chemistry For Changing Times, 6th Edition. Macmillan Publishing Co., New York, N.Y. 749 pp.

Selected Resources for Teachers

Hidden Treasure, a 1993 video on South Dakota ground water, produced by the South Dakota Geological Survey, and available in all high school libraries and in the South Dakota State Library, grades 9 through 12.
Nonpoint Source Pollution-Community; Nonpoint Source Pollution-Rural, two humorous 12-minute programs on one video cassette, produced and distributed by the South Dakota Department of Environment and Natural Resources. These videos are available in all South Dakota Conservation District Offices, the South Dakota State Library (under subject heading NPS), the South Dakota State University Instructional Media Library, the University of South Dakota I.D. Weeks Library, and the South Dakota NPS I&E Program office (telephone 605-773-5276).
Telephone 1-800-GET-DENR for additional information about water.
Study and Interpretation of the Chemical Characteristics of Natural Water, Hem, J.D., 1985, United State Geological Survey Water-Supply Paper 2254.
Numerous brochures and pamphlets are available from the United States Geological Survey.

Outreach (Resource Agency Personnel)

South Dakota Geological Survey, USD Campus, 414 East Clark Street, Vermillion, SD 57069.
South Dakota School of Mines and Technology, Geology Department, Rapid City, SD 57701.
South Dakota State University, Water Resources Research Institute, Brookings, SD 57007.
United States Geological Survey, Federal Building, Rm. 408, 200 4th Street SW, Huron, SD 57350.
United States Geological Survey, 1608 Mountain View Road, Rapid City, SD 57701.
University of South Dakota, Dept. of Earth Sciences and Physics, 414 E. Clark St., Vermillion, SD 57069.

Written by:
Sarah Chadima, South Dakota Geological Survey, University of South Dakota, 414 East Clark Street, Vermillion, SD 57069.

Reviewed by:
Dr. Samuel Gingerich, Professor of Chemistry, Northern State University, 1200 South Jay, Aberdeen, SD 57401
Derric Iles, South Dakota Geological Survey, University of South Dakota, 414 East Clark Street, Vermillion, SD 57069.

Publication of the *South Dakota Ground Water Quality* fact sheet was funded by the South Dakota Department of Game, Fish and Parks, Division of Wildlife, Pierre, SD.