Groundwater and Drinking Water

Introduction

Safe and reliable drinking water is essential for economic vitality and public health. Nearly every activity at some level in a community requires water for proper function—from homes, schools, and municipal services to commercial, industrial, and agricultural processes of production and waste treatment. The use of groundwater as a safe source of water supply has enabled communities to exist in locations without access to streams, lakes, or reservoirs. With increased population and economic activities that generate pollution, communities must be more vigilant in protecting their drinking water sources.

Although groundwater is generally considered to be "cleaner" than surface water because it is not directly exposed to surface contaminants, groundwater does accumulate anthropogenic and naturally occurring substances from its surroundings that, if left untreated, could be harmful to human health. The consequences of untreated water use can be seen worldwide, as tens of millions of people suffer from water-related illnesses,[1] with more than 800 children per day dying from water and sanitation-related diseases.[2] In the United States, however, drinking water is considered to be among the safest supplies in the world due to drinking water management and regulation, contaminant mitigation, and treatment.

Sources of Drinking Water

Groundwater systems provide nearly half of the world's drinking water,[3] which is delivered to populations via private and public water systems. In the United States, drinking water is available through both public and private water supply systems, with 86% of the population receiving water from public utilities.[4] Groundwater constitutes 37% of water used in public systems, equating to nearly 16 billion gallons of groundwater withdrawn and consumed per day. About 13.1 million households in the U.S. use an estimated 3.5 billion gallons of groundwater per day pumped from individual household wells[5] for their drinking water supply. Even areas that primarily rely on surface water for their water supply are still using discharged groundwater to an extent, as groundwater supplies about half of streamflow in the U.S.[6]

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Regulation of Public and Private Water Systems

Unimproved water sources and untreated water are associated with increased transmission and infection rates of diseases such as cholera, typhoid, and dysentery resulting from microbiological pathogens in water. To mitigate the spread of illness and promote public health, drinking water must be protected and regularly disinfected against microbial occurrence.

In the United States, 160,000 water systems serving 25 or more people are regulated to ensure their drinking water meets public health standards. As of 2016, approximately 38,600 of the 50,400 community water systems, which are a subset of all public water systems, use groundwater as their principal source of water.[7] These public water systems are subject to the Safe Drinking Water Act passed by Congress in 1974 and amended twice since originally enacted. The Act authorized the U.S. Environmental Protection Agency to set national standards for the quality of drinking water from public water systems and protect the delivered water from source to tap.[8] Public water systems are responsible for ensuring levels of these contaminants do not exceed the national standards by checking their water quality at specific sampling points.

Unlike public water supply systems, private residential well owners are not subject to national standards imposed by the Safe Drinking Water Act. Private well owners must take personal initiative to maintain the quality of their drinking water, including contacting local public health offices for construction and water quality testing requirements and well construction and maintenance advice. Local regulations often call for water testing at times of consulting service, or real estate transfer.

Drinking Water Source Protection

The first step to contaminant mitigation is to protect the source of water. Source water protection is accomplished by minimizing waste, chemical residuals, and microbes in water sources. Source water protection focuses on keeping contaminants away from wells and water intakes.

Wastewater Management

Water production also generates wastewater in need of treatment or disposal or both. If not properly disposed, contaminants removed from drinking water during treatment could result in ecosystem damage and spread of disease. Treatment byproducts may be disposed into landfills, released to waste treatment plants, injected into deep geologic strata, or, if permitted, discharged into surface waters.[9]

A wastewater management method used by one-third of the U.S. population is an on-site wastewater treatment system, which is often a septic tank system.[10] The U.S. EPA estimates as many as half of all septic tank systems in the country are not operating satisfactorily.[11] When improperly maintained or built in unsuitable soil conditions, septic systems may release pathogens into groundwater drawn on by nearby wells. In a New Mexico study, on-site septic systems have contaminated more groundwater than all other contaminant sources combined.[11] However, when properly constructed and maintained, septic tanks can be an effective alternative to centralized wastewater treatment systems.

Local geology and infrastructure development determine the degree and type of drinking water contamination.

The injection of waste into deep, porous rock formations has become an increasingly used means of brackish and saline wastewater disposal. After gaining acceptance in the 1930s, deep well injection is now responsible for disposing 89% of hazardous waste, equaling 9 billion gallons of liquid per year.[12] Typically confined to areas where groundwater is not used for drinking water, deep well injection—if produced water from oil and gas operations—takes place in 32 U.S. states.[13]

Non-Point Sources

Non-point source pollutants refer to pollutants that are derived from a broad area and are not easily traced to a single source. Once released into the environment, pollutants such as nitrogen runoff or acid mine drainage are difficult to capture and expensive to treat. Monitoring, preventing, and mitigating non-point sources are important for the delivery of groundwater safe for drinking purposes and is oftentimes more cost-effective than treating already contaminated water. For example, when an herbicide was found in the water supply of Burlington, North Carolina, the city made a one-time investment of $30,000 to eliminate the pollutant at its source, instead of spending the estimated $100,000 per year that would have been necessary to treat the water.[11]

Source water protection is accomplished by minimizing waste, chemical residuals, and microbes in water sources.

Well Inspection and Maintenance

In addition to keeping wastes, chemicals, and microbes away from wells, water systems and homeowners relying on groundwater should consider annual checks of the well and area around it. Wells should have locking caps to keep any substances from falling into the well casing. Well casing should also be inspected to ensure it is not damaged at the surface and that the concrete well apron is not cracked or damaged in any way that would allow contaminants to be released at or near the wellhead and travel down the outside of the well casing to the well screen and aquifer. If wellhead damage is observed, the well or apron can be repaired to provide protection of the water source. Wellhead protection should also include the surveillance of any human activity changes around the wellhead, such as increased automobile parking or farming activities, that could release pollutants affecting groundwater.

Drinking Water Treatment

Groundwater protection measures such as wellhead protection, land use management, or non-point source pollution control may be insufficient to deliver safe drinking water supplies, so treatment and disinfection are applied to further mitigate contamination and improve quality. While new water treatment processes are constantly being introduced, others such as distillation and chlorination have been used for generations to deliver safe water supplies. Chlorination, in particular, has remained the primary disinfection process in the U.S. since the early 1900s and continues to be so today in many types of treatment.

Household Treatment

Private well owners can treat their drinking water, as needed, by disinfecting their wells and installing treatment and disinfection devices at household “points of use” or “points of entry” to the house. Well owners should be conscious of local contaminants as treatments are most effective when appropriate devices are matched to the local concerns.[14] Boiling water, for example, may be efficient at removing harmful bacteria, but is ineffective at removing lead and nitrate. Household drinking water treatment can have considerable cost differences that are determined by the contaminant type and technology used. Implementing reverse osmosis and anion exchange technologies to treat arsenic and nitrate contamination may have an initial cost of $500 to $3000, with a $100 to $500 annual maintenance cost.[15] Microorganism treatment technologies, on the other hand, may range from $100 to $3000 in retail cost.[16]

Central Treatment

Water systems supplying large populations maintain water quality using a variety of treatment processes for a wide spectrum of concerns. The first two stages of water purification remove solid matter from the water using filtration, coagulation, and flocculation.[12] The third stage disinfects the water, removes unfavorable odor and taste, and adjusts the pH.[12] Once treated, the water can then be distributed to local consumers. The average cost for water in the United States is about $2 per 1000 gallons, of which 15% of the cost is for treatment.[17]

Blended Water

Mixing high-quality source water with lower-quality source water is a commonly accepted practice in areas affected by water scarcity. A blend of treated groundwater and surface water can also reduce contaminant concentration levels, helping the water supplier to meet drinking water standards. Blending local water sources to comply with drinking water standards may reduce the need to import water across long distances. In San Francisco, two-thirds of the city will soon receive a blend of 10% groundwater and 90% reservoir water from local sources.[18]

Desalination of Groundwater

Desalination of brackish groundwater that may be available in more arid areas is becoming an increasingly attractive method to provide safe drinking water as it may be more cost effective than importing water from distant sources.[12] As opposed to the simple chlorine treatment necessary for ensuring safe drinking water from freshwater, saline water requires an extensive treatment process to remove constituents such as boron, bromide, iodide, and potassium. Waste from desalination processes must then be disposed using appropriate methods.

Since desalinated water is low in minerals and can be corrosive to cementitious and metallic materials (such as pipes) during transmission or storage, it can be blended with safe groundwater sources that are not as corrosive as desalinated water to minimize infrastructure deterioration.

Threats to Public and Private Water Systems

While groundwater may be vulnerable to contamination from natural and anthropogenic threats, local geology and infrastructure development do determine the degree and type of untreated drinking water quality. Regions with high clay, limestone, and volcanic rock content, for example, are more likely to have increased levels of arsenic in groundwater.[15] Water systems located near or downstream of farmland, for example, may contain higher concentrations of nitrate from fertilizer, whereas water systems in urban areas are more likely to contain higher concentrations of organic chemicals from industrial wastes.

Naturally Occurring Contaminants

The quality of groundwater may be affected by natural processes, such as dissolution and biodegradation.[11] Naturally occurring constituents in groundwater samples account for about 74% of all contaminant concentrations present at unsafe concentration levels in drinking water.[19] Low levels of some naturally occurring elements—magnesium, calcium, and sodium—pose no significant threat to public health. Low concentrations of other constituents such as radionuclides, microorganisms, arsenic, and other trace elements, if untreated, may cause adverse health effects from long-term exposure and consumption.[21] These may require additional treatment to ensure public health.

Distillation and chlorination have been used for generations to deliver safe water supplies.

Anthropogenic Contaminants

In an increasingly developed world, human activity has become a dominant threat to clean water supplies. Agricultural practices are responsible for the release of animal waste, pesticides, and fertilizer into groundwater, with nitrate from fertilizer application considered the world's most common chemical contaminant in aquifers.[2] Municipal sewage, commercially-used chemicals, and industrial waste are also among the primary sources of human-induced contaminants affecting the quality of groundwater. These sources of human-made pollutants in groundwater have resulted in one-fourth of the human health compliance measurements of contaminant concentrations greater than EPA's drinking water maximum contaminant levels.[19]

In addition to chemical pollution, viral and bacterial pathogens from human waste are also a threat to drinking water supplies because they can lead to waterborne diseases such as cholera and dysentery. Between 2011 and 2012 (more recent data will soon follow), drinking water in the U.S. was associated with 32 disease outbreaks, of which more than half were related to the use of surface water sources.[20] The subsurface environment of groundwater provides some level of natural treatment for many microbial contaminants that is not typically inherent to surface water.

Corrosion of Water Systems

Corrosion of water pipes can affect drinking water quality. Water pipes made with lead or connected with lead solder and corroded by acidic water may leach very small concentrations of toxic metals, such as lead or copper, into drinking water. While lead is typically not present in source water, it may be present in drinking water supplies, such as the case of Flint, Michigan, where corrosion induced lead leaching from piping systems. A recent USGS study of 20,000 wells across the country identified 25 states having a high prevalence of potentially corrosive groundwater.[22] These findings have the greatest implication for people dependent on untreated groundwater from domestic wells or springs for their drinking water supply.

In addition to a public health concern, failure to monitor and treat water acidity results in expensive repair and replacement of water and wastewater pipes. Approximately 876,000 miles of municipal water piping have been installed underground in the United States[23] that are scheduled to be evaluated every four years to determine their condition.[24]

The maintenance and improvement of groundwater quality is also the maintenance of drinking water quality. Nearly half the drinking water in the world, as well as in the United States,[3] is from groundwater sources. Thus, a significant portion of the population depends on groundwater monitoring, regulation, protection, and treatment to safeguard public health. As the demand for clean water grows with an increasing population, groundwater and its management will continue to be important for drinking water supplies into the future.

Works Cited

1 **National Academy of Sciences.** *Safe Drinking Water is Essential.* [Online] 2007. [Cited: January 13, 2017.] https://www.koshland-science-museum.org/water/html/en/Overview/Why-is-Safe-Water-Essential.html.

2 **United Nations.** *Water for Life Decade.* [Online] 2014. [Cited: November 11, 2016.] http://www.un.org/waterforlifedecade/quality.shtml.

3 **Smith, M., K. Cross, M. Paden, and P. Laban.** *Spring—Managing groundwater sustainability.* Gland, Switzerland: IUCN, 2016.

4 **USGS.** *Public Supply Water-Use.* [Online] 2016. [Cited: November 10, 2016.] http://water.usgs.gov/watuse/wups.html.

5 **National Ground Water Association.** *Groundwater Use in the United States of America.* [Online] 2016. [Cited: November 10, 2016.] http://www.ngwa.org/Fundamentals/Documents/usa-groundwater-use-fact-sheet.pdf.

6 **Wellowner.org.** *Groundwater Supply & Use.* [Online] 2010. [Cited: November 11, 2016.] http://www.wellowner.org/groundwater/groundwater-supply-use/.

7 **U.S. EPA.** *GPRA Drinking Water Inventory Summary Report.* [Online] 2016. [Cited: January 24, 2017.] https://obipublic11.epa.gov/analytics/saw.dll?PortalPages.

8 **U.S. EPA.** *Understanding the Safe Drinking Water Act.* [Online] 2004. [Cited: November 10, 2016.]

9 **Job, C.A.** *Groundwater Economics.* Boca Raton, Florida: CRC Press, 2010.

10 **Lustgarten, A.** *Injection Wells: The Poison Beneath Us.* New York, New York: ProPublica, 2012.

11 *Groundwater Report to the Nation: A Call to Action.* 1st ed. Oklahoma City, Oklahoma: Groundwater Protection Council, 2007.

12 **Roberts, C.** *Blending contaminated SF groundwater with Hetch Hetchy supply makes it safe to drink, experts say.* San Francisco, California: The Examiner, 2014.

13 **Guinn, C., and J. Berti.** *Class One Injection Wells.* [Online] 2016. [Cited: November 11, 2016.] http://people.uwec.edu/piercech/HazwasteWebsSp04/DeepWellInjection/DeepWellInjection.htm.

[14] **Water Systems Council.** *Drinking Water Treatments.* [Online]. [Cited: December 8, 2016.] https://www.watersystemscouncil.org/download/wellcare_information_sheets/well_water_testing_&_treatment_information_sheets/7968594INSERT_TREAT.PDF.

[15] **National Ground Water Association.** *Reducing Problematic Concentrations of Arsenic in Residential Water Well Systems.* Westerville, Ohio: 2016.

[16] **National Ground Water Association.** *Reducing Problematic Concentrations of Microorganisms in Residential Water Well Systems.* Westerville, Ohio: 2013.

[17] **U.S. EPA.** *How much does it cost to treat and deliver drinking water?* [Online]. [Cited: January 24, 2017.] https://safewater.zendesk.com/hc/en-us/articles/211400478-How-much-does-it-cost-to-treat-and-deliver-drinking-water.

[18] **Scalf, M.R., W.J. Dunlap, and J.F. Kreissl.** *Environmental Effects of Septic Tank Systems.* U.S. EPA, 1977.

[19] **Toccalino, P., and J. Hopple.** *Quality of Water from Public-Supply Wells in the United States,* 1993-2007. Reston, Virginia: USGS, 2010.

[20] **Beer, K.D. et al.** *Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water–United States,* 2011-2012. Morbidity and Mortality Weekly Report, 2015, 64(31).

[21] **National Ground Water Association.** *Groundwater Protection.* [Online] 2016. [Cited: November 10, 2016.] http://www.wellowner.org/water-quality/groundwater-protection/.

[22] **Demas, A.** *New Study Shows High Potential for Groundwater to be Corrosive in Half of U.S. States.* Reston, Virginia: USGS, 2016.

[23] **NACE International.** *Corrosion Costs and Preventive Strategies in the United States.* Houston, Texas: 2002.

[24] **Drinking Water Protection Division.** *Drinking Water Infrastructure Needs Survey and Assessment.* Washington, D.C.: U.S. EPA, 2007.

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