THE AMERICAN WELL OWNER

★ INFORMATION AND ADVICE ABOUT GROUND WATER, WELLS AND WATER SYSTEMS ★

A Quarterly Publication for Well Owners - 2002 Number 3

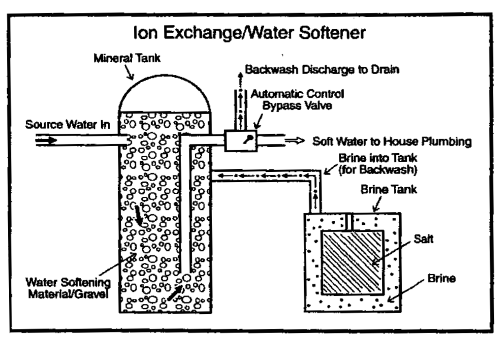
Solutions to Iron Problems

An elevated level of iron is a common water quality issue for well owners. Iron makes up five percent of the earth's crust and occurs in most ground water in dissolved form. It is dissolved from the rocks and minerals that form aquifers. Generally, the longer the ground water is underground and flowing through cracks and pores, the higher the iron concentration is likely to be.

Iron is a beneficial and necessary nutrient in most adult diets and the US Environmental Protection Agency (EPA) does not consider elevated iron concentrations in drinking water to be a health problem. Most people get their daily minerals and vitamins through the food they eat and not the water they consume.

The first step in solving an iron problem is to determine if the iron is in particle form (oxidized state) or dissolved form (reduced state). The color of the water is a good initial clue for the presence of oxidized iron. Iron that is oxidized forms small "rust" particles that can give the water running out of a faucet a red, brown or yellow color. Oxidized iron must be removed with a mechanical filter that will catch the small particles before they pass into the home plumbing and/or other water conditioning equipment.

Dissolved ("clear water") iron in ground water may become oxidized once it is exposed to oxygen in the air. Agitating the water or adding oxidants such as clothes bleach or other home cleaners containing chlorine can accelerate this process. As the water becomes oxidized, it can stain plumbing fixtures and clothes. To help prevent problems with iron staining, the EPA has recommended an upper concentration limit of 0.3 parts per million (ppm or milligrams per liter [mg/L]) dissolved iron.



There are several treatment methods for dissolved iron. In many cases, they are similar to those used to remove manganese and/ or sulfur. For situations with iron concentrations up to 2 or 3 ppm, typical water softeners (using salt [NaCl] brine for regeneration) are likely to be effective. The sodium resins in these systems actually prefer the iron to the "hardness" elements such as calcium and magnesium. If the iron concentrations are greater than 5 ppm iron then the

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MESSAGE FROM THE PUBLISHER

DROUGHT IN 2002 – WARNING FOR THE FUTURE?

The persistence of drought conditions, despite some occasional rain events, has caused on-going problems for water supply in many parts of the US. In many instances a short-term "fix" was achieved by conservation measures and water restrictions that "shared-out" the reduced supply among water utility customers. Although many wells were not directly affected, where the drought did have an impact, well owners also reduced consumption and some deepened their wells or added additional tank storage.

Too bad for the farmers who lost crops, but there was no disruption to food supply because in time of drought we can supply food needs by transporting produce to where it is needed. We can't solve regional drought problems quite so easily. We have to manage on the resources available. The drought of 2002 could serve as a warning. There will be an additional 100 million people in America by 2050. Home water systems based on wells that are designed with adequate storage, are likely to be an increasingly important solution to regional droughts for rural and suburban areas. Even a low yielding well of half a gallon a minute can supply 700 gallons a day!

Take care of your well and recognize the value of our precious ground water resources.

Andrew Stone

Andrew W. Stone
American Ground Water Trust

Helping communities, residents, businesses and farms that use water wells maintain safe, reliable, cost-effective water supplies and ensure a sustainable local environment.

SOLUTIONS TO IRON PROBLEMS . . . *continued from page 1*

treatment must be specially designed to ensure that the "backwash" regeneration cycle is strong enough the remove and wash away the dissolved iron that is collected out of the raw water. Treatment with a water softener works best when the pH of the water is near neutral (pH=7).

Higher concentrations of dissolved iron require more aggressive oxidation treatment with aeration, chlorine compounds or ozone. Each of these methods converts dissolved iron into ferric (oxidized) iron that can be trapped by a filter. In the first case, aeration adds oxygen to the water by vigorously blowing air into the water or by cascading the water over trays. The water is filtered at the end of the aeration process.

Ozone is a stronger oxidant than chlorine, but ozonation equipment is typically more expensive to operate because of higher electricity consumption. In either case, the raw water is placed in contact with either ozone gas or chlorine. Most residential systems use a solution of calcium hypochlorite or sodium hypochlorite rather than chlorine gas as the chlorine source for the treatment. Following treatment with ozone or chlorine the water is held in a tank to allow time for the oxidation process to be completed and then filtered prior to use. Chlorine systems may also include a treatment with activated carbon to remove residual chlorine before entering the domestic drinking water supply.

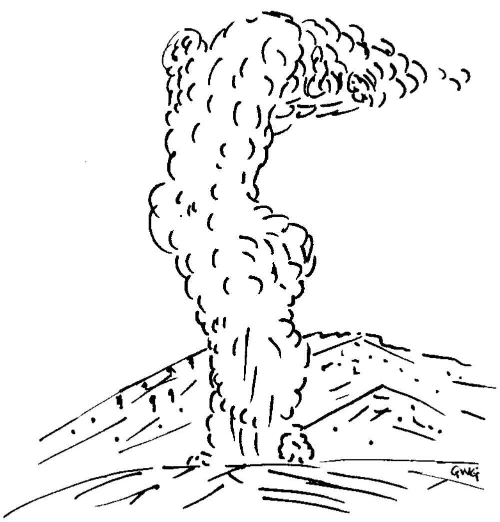
Another common method uses an oxidizing filter media known as "greensand." A bed of greensand comprised of manganese oxide coated resin pellets/ beads provides both an oxidizing environment and filtering capacity. Oxygen is released from the manganese oxide coating to oxidize the dissolved iron in the raw water passing through the bed. The oxidized iron particles are trapped in the resin bed until removed during the backwash cycle when the manganese oxide coating is regenerated with potassium permanganate. The iron particles must be flushed out during the backwash cycle so that the resin bed does not become clogged. Greensand systems do not require high dissolved oxygen contents, but work best when the water pH is above 7.5.

Polyphosphate treatments do not remove iron (or manganese) from the raw water. They reduce staining by retaining these metals in solution and preventing oxidation. This method is only effective for levels of iron and manganese less than about 1 ppm and if the water will not be heated. Heating releases the metals and allows oxidation to occur.

Water quality problems are not always straight forward to solve. Be sure to get a written contract with your water treatment installer that specifies how any lingering water quality issues will be addressed, who will by responsible financially and what will be done if a water quality concern cannot be satisfactorily treated.

GEYSERS - HOW DO THEY WORK?

We are used to ground water being described as slow moving. Geysers are dramatic exceptions! A geyser is a hot spring that periodically jets a stream of boiling water and steam out of the ground. The name is derived from the Icelandic word "geysir" that means "to rush forth" and the "Great Geysir" located in the town of Huakadalur in southwestern Iceland. Geysers are associated with active volcanic regions around the world where ground water is heated as it infiltrates to hot zones in the earth's crust.



To understand how a geyser works we must understand that the temperature at which water boils rises with increasing pressure. At sea level ("one atmosphere pressure" or 760 millimeters of mercury) water boils at 100 degrees Celsius (212° Fahrenheit). In Denver, Colorado, USA, also known as the "Mile High City," atmospheric pressure is less than at sea level and water boils at about 95° Celsius (203°F). Just the opposite happens when water is at greater pressure in the earth's crust. High pressures increase the temperature required to boil water deep underground.

Geysers are comprised of an intricate series of fractures and cracks. Narrow constrictions within the network of fractures act as pipes. When the fracture system is full of water, the pressure at the bottom of the geyser system is at a greater pressure, due to the weight of the overlying water column, than the water at the top of the geyser near the opening. The greater pressure at the bottom of the geyser keeps the deep water from boiling even though temperatures may reach 150°C (302°F) or more. If the pressure of the overlying water column is reduced in some way, the effect is an immediate pressure drop throughout the water column in the geyser. This can initiate instantaneous high-temperature violent boiling at the bottom of the geyser that forces the water explosively out of the throat and mouth of the geyser. One mechanism that may start the process is for the water at the top to boil to the point where water (and pressure) is lost out of the geyser system allowing progressively deeper water to boil. The zone of boiling continues downward rapidly and increases in intensity forcing the water column out of the geyser.

"Cold water" artesian (free flowing) wells and springs should not be confused with geysers. Artesian wells flow because they are under pressure from a confined source of water that pushes the ground water out of the well without boiling.

What have we done to the Ogallala Aquifer?

The Ogallala aquifer is the largest aquifer in the United States and one of the largest aquifers in the world. It is referred to as the High Plains aquifer in most technical reports because it underlies portions of eight states in America's central "high" plains (predominantly Nebraska and Kansas, and parts of Oklahoma, Colorado, New Mexico, Texas, South Dakota and Wyoming) encompassing an area of about 174,050 square miles. As with most aquifers it receives recharge [new] water primarily through infiltration of rain and snow melt from the surface. The recharge water fills fractures and interstices (open spaces between rock particles) in the rock.

The Ogallala formation is the main rock unit of the High Plains aquifer and is named after the town of Ogallala in southwestern Nebraska where the rock is exposed at the surface. It is comprised of clay, silt, sand and gravel that were deposited in streams that drained from the Rocky Mountains during the late Tertiary geologic time period (about 5 to 10 million years ago). The Ogallala is up to 215 meters (705 feet) thick, and in the Sand Hills area of central Nebraska the Ogallala formation is covered by sand dunes.

The nomadic hunter-gather culture and later subsistence farming activities of the Native Americans had little impact on the water stored in the Ogallala aquifer. In 1854, the Halladay wind pump was introduced to the high plains to provide water for irrigation and, somewhat later, to replenish railroad steam engines. More efficient steel blades replaced wood fan blades in the 1870's and the withdrawal of water from the Ogallala aquifer was permanently established. Beginning in the early 1940's and increasingly after the end of World War II, high discharge gas-powered center-pivot turbine pumps were employed in many areas over the Ogallala aquifer.

These large capacity pumps have withdrawn water at a rate that significantly exceeds the recharge back to the Ogallala aquifer. The United Nations estimated in its 1996 Comprehensive Global Freshwater Assessment that withdrawals from the Ogallala aquifer exceed recharge by approximately 3 to 1.

In 1980, the Ogallala held about 3,250 million acre-feet of drainable water according to the United State Geological Survey (1 acre-foot equals 325,805 gallons). Since then, the aquifer has lost a large volume of this water through withdrawals for agricultural uses. The average annual fall in the water table of the aquifer between 1980 and 1999 according to the USGS was 3.2 feet. The largest declines were in southwest Kansas and the Texas Panhandle. In these two regions, the average decline was near 25 feet, but had maximums greater than 67 feet. In eastern Nebraska, there were local areas where the water table rose by over 30 feet. The areas showing a rise in the water table were much smaller in extent than the areas showing declines.

The average saturated thickness of the Ogallala aquifer in Kansas and Texas is slightly over 100 feet. As the water table falls it becomes more expensive to withdraw water due to increased pumping costs. Without conservation of the resource, large areas of the aquifer will be depleted in the next two decades. This condition will have significant impacts on society in these areas of the United States and on the agricultural economies that rely on production from these regions.

Further reading:
Quick facts (1994 data): http://www-ne.cr.usgs.gov/highplains/hpchar.html
Water level change information [1980 to 1999]: http://ne.water.usgs.gov/highplains/hp_99_web_report/FS-029-01.pdf
Aerial photos of Southwest Kansas between 1974 and 1989: http://www.cossa.csiro.au/lb/lbbook/agric/ag18.htm
Prevailing water requirements of the United States: http://www.kerrcenter.com/RDPP/Ogallala2.htm

Drought and Ground Water *continued from page 4*

particular substance (e.g., sediment, radon, hydrogen sulfide (rotten egg odor), etc). In this case, the concentration of the substance in the well water may be significantly affected by this part of the cocktail mixture. During a drought or period of seasonally low water, some fractures may go dry before others and thus change the chemistry of the water. When the "normal" water level returns the former water chemistry conditions are likely to return.

The Trust recommends testing well water annually for bacteria and nitrates, or whenever you notice a significant and persistent (continuous for several days) change in the aesthetic quality (odor, taste, color) of your well water. Before making an investment in a water treatment system it may be prudent to wait a few months to see if the quality will return to normal as the ground water levels change with the seasons or the end of the drought. In most cases ground water levels are highest in the spring and lowest in the fall.

Additional Sources:
National Oceanic and Atmospheric Administration (NOAA) Website:
What is drought?: http://www.drought.noaa.gov/
What regions of the United States are in drought?:
http://www.cpc.ncep.noaa.gov/products/expert_assessment/drought_assessment.html

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TOPICS IN UPCOMING ISSUES

- **What are Iron Bacteria?**
- **Water Treatment - Ozonation**
- **Solutions to Hardness Problems**

Drought and Ground Water

"We know the value of water when the well runs dry." - Benjamin Franklin

A drought is defined as a period of abnormally dry weather that persists long enough to produce significant water supply problems in a particular area. The severity of a drought is related to the size of the area affected, the magnitude of the water deficiency and how long the drought condition persists. Currently about one-third of the United States is in a moderate to extreme drought condition.

A drenching rain storm is a welcome event during a drought, but it may not have a big impact on replenishing the ground water supply if the stormwater runoff volume is high because of large areas of impervious development (pavement, roof tops, lawns vs. woods), or if the volume of water exceeds the ability of the natural soil to accept the flow as fast as it arrives at the earth's surface. Once infiltration begins it still may take weeks for the water to seep down to become ground water. During drought, well owners may deepen wells seeking additional water-bearing fractures. Storage capacity may be increased by drilling wells deeper or by installing tanks in basements (follow local regulations for this work), but the total amount of ground water available on a daily basis to private well owners or a municipal well system will not increase until infiltration and recharge increase as the drought abates.

During drought, water well yields may decline and potentially cause a change in the quality of the water. Changes result from the drought's affect on the "mixture" of water in the well. As we draw water from a well new (i.e., recharge) water flows into the well from fractures and pore spaces in the rocks surrounding the drilled hole.

There may not be enough rain during a drought to replenish the water in a shallow bored or dug well because the recharge is typically obtained from recent precipitation (rain or snow) in a matter of hours or days. The water quality usually remains consistent in a shallow well even with a reduction in the quantity of water because the water recharging the well has had little time to react chemically with the surrounding rock. However, the quality (increased odor, cloudiness [sediment], and bacteria, etc.) may change quickly just before the well actually goes dry, especially if the pump intake is near the bottom of the well.

Water from deep bedrock wells may represent a "cocktail mixture" of water added from different fractures and rock layers that the recharge water contacts during its travel to the well from the surface. Generally, the fracture supplying the most of the water will have the greatest impact on the quality of the water in the well. This might not be true if a "small" fracture supplies a modest volume of water, but with an unusually high concentration of a

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