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Where Have You Been for the Past 25 Years?

Nonpoint Source Pollution is a Bigger Threat to Groundwater than the Keystone XL Pipeline

By Jane Griffin, Groundwater Foundation President

Who would have guessed that it would be a proposed pipeline that would put in evidence the concern for and interest in an aquifer and the life-sustaining resource it contains: groundwater. But, boy, it sure has. It almost seems as if the fate of the pipeline equates the fate of the aquifer. Instead, the one indisputable fact relevant to this discussion is this: no matter what the outcome is of the proposed Keystone XL pipeline, there will continue to be issues that strain or put our water supply at risk as our society grows and evolves.

It doesn't take an expert to predict this; in fact, all you need to do is look at the situation today and you will find a multitude of existing contaminants and risks that currently threaten our aquifer systems. Which logically begs the question: where have you all been for the past 25 years? And will your declared allegiance to the resource remain strong?

The Ogallala Aquifer is the principle aquifer in the High Plains Aquifer system and the main aquifer beneath the state of Nebraska. Groundwater is the water beneath our feet, but it is not an underground ocean, lake or river. It is the water contained between the sand, soil and rock particles that make up the geological formation that contains it: the aquifer. Groundwater is like the water in the sponge, the sponge being the aquifer.

Additionally, just as much as we rely on groundwater (it supplies the drinking water for over 85% of Nebraskans, 50% of Americans, and is a major source of irrigation to grow our food) groundwater relies on us to protect and conserve it. In fact, the quality of our drinking water is largely dependent on our actions; while some contamination occurs naturally, the majority of source water pollution is the result of human actions.[1]

So what actions are creating these threats to our water supply?

Existing Threats

First, let's define a couple of important things: point source and nonpoint source pollution. Point source pollution occurs when you can identify exactly where a pollutant is coming from, such as discharge from a factory; chemical storage tanks; septic tanks and drainfields; leakage from underground storage tanks, pipelines and sewers; sewage lagoons; sanitary landfills; and improperly filled, sealed or constructed private wells. These are all elements that are present in urban and rural communities and all need to be managed properly.

Conversely, nonpoint source pollution cannot be identified as coming from a specific source; for example, runoff from fertilizer or salt solution used on city streets during the winter. Due to its nature, nonpoint source pollution is obviously the more difficult beast to battle. This clearly stands true in Nebraska and many other states that are faced with nitrate contamination of groundwater. Nitrates come from nitrogen sources, such as fossil fuels, fertilizer, human and animal waste. They are important for plant growth, but, just as the saying goes, too much of a good thing becomes a bad thing. Plants can only utilize so much, and the excess enters the soil and leaches to the groundwater or runs off the land directly into surface water. While efforts are in place to reduce nitrate contamination, the bulk of what is being done does not address the source of the problem – it is limited to reactionary efforts, including installation of water treatment plants, closure of wells or entire communities' water system. This

Pipeline, *continued on page 4* ▶

INSIDE

Mission of The Groundwater Foundation:
To educate people and inspire action to ensure sustainable, clean groundwater for future generations.

Groundwater Shorts

EPA Develops New Planning Approach to Improve Water Quality

The U.S. Environmental Protection Agency has announced a commitment to using an integrated planning process to help local governments dealing with difficult financial conditions identify opportunities to achieve clean water by controlling and managing releases of wastewater and stormwater runoff more efficiently and cost effectively. The integrated planning process will help municipalities prioritize infrastructure investments to address the most serious water quality issues and provide flexibility to use innovative, cost-effective stormwater and wastewater management solutions.

Aging sewer systems, not designed to handle heavy rain and snowfall in addition to handling the wastewater from growing populations and local industries, can overflow, releasing untreated sewage into waterways, onto city streets or into the basements of homes. As the runoff flows over the land or impervious surfaces, including paved streets, parking lots, and building rooftops, it accumulates debris, chemicals, sediment and other pollutants. Overflows and stormwater can carry a variety of harmful pollutants, including bacteria, metals and nutrients that threaten communities' water quality and can contribute to disease outbreaks, beach and shellfish bed closings, flooding, and fishing or swimming advisories.

To better protect water quality, EPA will work with local governments to review the Clean Water Act requirements that each municipality must comply with and look for opportunities to improve the efficiency and effectiveness of solutions developed to meet those obligations. This integrated approach will identify efficiencies where more than one water quality issue can be addressed by the same solution and where competing requirements may exist, including how to best make capital investments and meet operation and maintenance requirements.

Integrated planning approaches can also have other benefits, like leading to the identification of innovative, sustainable solutions that improve water quality and enhance community vitality. Green infrastructure, such as green roofs, rain gardens, planter boxes, and permeable pavement, is an example of an integrated solution that can reduce, capture, and treat stormwater runoff at its source before it can reach the sewer system. Green infrastructure provides a cost effective way to reduce overflows and add green space in communities.

Visit http://cfpub.epa.gov/npdes/integratedplans.cfm for more information.

Upgrading Water Systems Can Reduce Pollution and Create Jobs

Want to create nearly 1.9 million American jobs and add $265 billion to the economy? Upgrade our water and wastewater infrastructure. That's the message of a recent report released by Green For All, in partnership with American Rivers, the Economic Policy Institute and the Pacific Institute, with funding generously provided by the Rockefeller Foundation.

Every year, sewage overflows dump 860 billion gallons of untreated sewage into our water systems – enough to cover the entire state of Pennsylvania with waste one-inch deep. But investment in our nation's infrastructure to handle stormwater and wastewater has lagged, falling by one-third since its 1975 peak.

The report, Water Works: Rebuilding Infrastructure, Creating Jobs, Greening the Environment, looks at an investment of $188.4 billion in water infrastructure – the amount EPA indicates would be required to manage stormwater and preserve water quality. That investment would inject a quarter of a trillion dollars into the economy, create nearly 1.3 million direct and indirect jobs in related sectors and result in 568,000 additional jobs from increased spending.

Further, the report notes that now is the best time to make the investment. With the recession creating a shortfall of 11.1 million jobs that would be needed to keep pace with the population and 9.1% unemployment, these are jobs that are critically needed. Moreover, the cost of financing these essential upgrades is at historic lows, and the still-struggling economy means much cheaper construction costs. Investing in green infrastructure approaches that more closely mimic natural systems is part of the solution – and further provides the additional benefits of reducing pollution of creeks and other waterways, saving energy, and increasing green space in urban areas.

The full report is available online at http://bit.ly/WaterWorksReport.

USGS Report Evaluates Carbon Storage in Ecosystems

The U.S. Geological Survey (USGS) recently published a study that examines the current and projected future carbon storage in the Great Plains region, as part of a nationwide assessment.

This is the first regional report applying a comprehensive methodology designed by the USGS in 2010 to assess how much carbon is stored in various ecosystems, such as wetlands, forests and rangelands. The study covers an area of the U.S. that includes parts of 14 states from eastern Montana to southern Texas and eastern Iowa. The full national assessment is expected to be completed around 2013.

A key finding in the Great Plains study is that the region is currently an overall "carbon sink," meaning it takes up more carbon than it emits. In addition, the amount of carbon sequestered offsets most of the emissions of nitrous oxide and methane from this region.

On a national scale, the amount of carbon that is currently stored per year in ecosystems within the Great Plains is about 21 percent of emissions from personal vehicles and 3.6 percent of total fossil fuel emissions nationwide. The values for vehicle and total fossil fuel emissions are not part of the USGS study but were calculated using the 2009 EPA national greenhouse gas inventory report.

"For the first time, we will have a comprehensive view of how carbon is cycling through our Nation's ecosystems: sources, sinks, and relative residence times in the various biological components," explained USGS Director Marcia McNutt.

The report "Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in the Great Plains Region of the United States" can be found online in the USGS publications warehouse at http://pubs.usgs.gov/pp/1787/.

How Can You Make A Difference?

Thoughts from the Board Chair

by Warren Arganbright, Groundwater Foundation Board Chair

The current election cycle has drawn more interest, more potential candidates, more money and for a longer period of time than I can ever recall happening. But it pales in comparison to the attention groundwater has drawn, at least in Nebraska, with the (previously) proposed route of the Keystone XL pipeline over the Ogallala Aquifer. Organizations and people we never heard from zealously proclaimed their interest in protecting the Ogallala Aquifer. But like Foundation President Jane Griffin said in a recent article (see page 1 of *The Aquifer*), "Where have you been for the past 25 years?"

The Groundwater Foundation has had, as its basic guiding principal for over 25 years, the concept of education, not only about groundwater in general, but about the importance of developing clean, sustainable groundwater use. However, the potential threats to our groundwater are much broader than things we can see, like a pipeline. It's the things we can't see that need our attention, things that, since they don't receive broad media attention, many people don't know or even think about.

I am not a scientist, a biologist, nor even a statistician. But as a resident of the Sandhills of Nebraska, I am a steward of the aquifer because I live over and use the largest aquifer in North America. I see the results of a clean, sustainable aquifer as evidenced by ancient fens, boiling springs, spring-fed lakes, streams and rivers, artesian wells, sub-irrigated meadows and irrigated crops. And I have personally seen the effect of pollution of that groundwater as well, one that required the installation of a reverse osmosis treatment system on the well serving our houses at the ranch north of Valentine in north central Nebraska. Water testing indicated hazardous levels of nitrates.

This, in an area where there is no large population center, where there is minimal farming and fertilizing, no confined concentrated animal feeding operations, and where the primary use of the land is livestock grazing. In the Sandhills, in Nebraska. Who knows where it came from?

This kind of pollution is called nonpoint source pollution. Because it cannot be identified as coming from any particular location or specific source, nonpoint source contamination is difficult to address. It ranges from chemical runoff from farming, to chemicals used on streets, lawns, and turf areas, to livestock waste, just to name a few.

Think about the things we have done, and still need to do, to sustain the qualities of the aquifer. The Groundwater Foundation has a program call Groundwater Guardian Green Sites, which encourages managers of green spaces such as golf courses and parks, to measure, document and implement groundwater-friendly practices related to chemical and water use, pollution prevention and optimal water quality. The Groundwater Foundation also offers a variety of other programs and opportunities to get involved, including Groundwater Guardian, free webinars, youth programs, and more to allow people to learn more about groundwater and take action on its behalf.

We can all contribute to a healthy aquifer. Even if you don't manage a golf course, you can make a difference. Become a Groundwater Foundation member. Encourage your community to become a Groundwater Guardian. Teach youth about groundwater and its importance. Conserve water in your home and at work. Visit www.groundwater.org to learn more.

And remember, groundwater is a fragile, finite resource. Help The Groundwater Foundation spread the word about maintaining a clean, sustainable resource.

If you don't, who will?

happens because public water systems are regulated by the U.S. Environmental Protection Agency. EPA standards dictate that nitrates cannot exceed 10 milligrams/liter.

In The Groundwater Foundation's home state of Nebraska, over 32 percent of groundwater wells tested across the state in 2009 exceeded nitrate standards (NDEQ 2010 Groundwater Monitoring Report). This only represents a portion of the full picture. Only public water systems are required by law to be tested (it is the responsibility of the homeowner to test the water quality of their well). Unfortunately, we know that the full picture does not get any better if we consider recent findings in USGS Circular 1350, "Nutrients in the Nation's Streams and Groundwater 1992–2004," which found "nitrate contamination of groundwater used for drinking water, particularly in shallow private wells in agricultural areas, is a continuing human-health concern and that excessive nutrient enrichment is widespread in streams. Despite major Federal, State, and local efforts to control point and non-point sources and transport of nutrients, concentrations of nutrients have remained the same or increased in many streams and aquifers across the Nation since the early 1990s." It is important to remember that nitrates can persist in groundwater for years or decades, so while it is vital to implement better management practices, the results may not be apparent for years.

So, is the answer simply to stop using fertilizer? While it may seem logical, it truthfully is not feasible. The world's population recently surpassed seven billion and is expected to reach nine billion in only a few decades, increasing the demand for food and posing significant challenges for agriculture. It is imperative to focus on improving existing technology and integrating new and better ways to ensure that we are meeting this mandate, but doing it in a way that will not negatively impact other parts of our delicate ecosystem.

Let's not forget about those of us who live in urban settings. We too are contributing to the nitrate load. Improper use of fertilizer is also an issue in urban settings. We all enjoy our green lawns and thriving gardens, and there is no reason we shouldn't; but we need to be aware that we can achieve rewarding results without creating unintended environmental degradation. Not all of us has the opportunity to become a horticulture or turf expert, but we can take a few simple steps to ensure we are good environmental stewards. The easiest thing to do is to read the instructions on product packages and follow the recommended application. After applying the proper amount of fertilizer to your lawn, sweep up any excess on surrounding sidewalks, streets or driveways, or the next rain or watering will wash them directly down the storm sewer and into a stream or river.

This approach works! The Groundwater Foundation's Green Site program has documented and showcased the positive environmental impact that constituents in typically more urban settings have achieved. The program assists and recognizes turf managers for adopting groundwater-friendly practices. It has produced significant data to demonstrate that individual actions do make a significant collective impact. Approximately 150 sites participate and have reduced fertilizer applications by over 770,000 pounds by basing applications on nutrient analyses.

There are other things that we as individuals and as members of communities can do to ensure needed practices are being implemented. We can be proactive and focus on the root of the problem, rather than waiting for the punitive or regulatory "reactions" such as the construction of a treatment plant. This "reaction" translates into a huge investment of millions of dollars, plus annual maintenance and required training for treatment plant operators. While this can be a costly, but feasible, solution for a larger community, many smaller communities cannot afford this option. Other options include drilling new wells and hooking up to a neighboring community's water system, but these are not always feasible either.

Instead, we can make proactive efforts to prevent supplies from becoming contaminated. One of the most effective measures to take is a wellhead protection plan to prevent drinking water from becoming polluted by managing potential sources of contamination in the area that supplies water to a public well.

Future Threats

Now, let's look at issues looming on the horizon, which brings us back to one of the primary issues surrounding the pipeline: energy. We cannot ignore our society's overwhelming need for energy, which dictates the development of new technologies and consumption patterns. There are many new sources of energy, but the technology and processes needed to capture and supply it to end users is complicated. One such process that has recently received a lot of coverage in the media is hydraulic fracturing, or fracking. Hydraulic fracturing has been touted as an important part of the solution to lower our dependence on foreign oil. It is part of a process to extract oil and natural gas from deep in the earth's subsurface by drilling deep into the earth's crust and injecting a blend of water, sand and chemical compounds, causing cracks in rock formations. These cracks then allow natural gas and oil to flow and be captured for energy production. While this, to date, has not been an issue nationwide, it could potentially be. What does this mean for us? It means we need to know more about the process and what the effective benefits are as well as the potential risks. What are the risks of water contamination? How much water is needed for the process? What is done with the waste products from the injection procedure?

The risks of contamination and water consumption for energy production are not limited to hydraulic fracturing. Other sources of energy, including solar, wind, biomass, nuclear, geothermal, water, etc., all have their own set of potential negative impacts. We need to look at our energy consumption today and realistically plot out a solution to reducing our dependence on our dominant energy sources while taking into consideration the impact of new technologies. We cannot expect there to be a panacea. The solution is going to be found by identifying and developing a combination of multiple energy options. This will take time, as well as educated and motivated youth to tackle this 21st century problem. Therefore we must invest in educating our youth in the fields of science, math, technology and engineering, and also ensure youth are interacting with nature and understanding our complex ecosystems. Today's youth will be tomorrow's decision makers. If their assumptions and understandings of nature are incorrect, how can they make informed decisions? In our work with youth we have seen how the connection to nature is often missing. For example, the simple understanding that everything that we use in our daily lives comes from the earth is often a major revelation. It is that type of awareness, combined with education, that produces a generation of capable leaders who seek out sound information and solutions, understand the need

to weigh the pros and cons of all decisions and, implement practices and influence policy makers in ways that ensure meeting long-term societal needs.

Does that mean we wait for the next generation to solve the problems that have been created? No, we must take to heart the Native American proverb: "We do not inherit the earth from our ancestors; we borrow it from our children." As such, we need to take a hard look at our consumption patterns, as individuals, as groups, as businesses, as communities. We can and must do better.

Harnessing the Energy

This brings us back to our central question: Can the energy and the concern that the Keystone XL pipeline has generated be harnessed into on-the-ground protection efforts to safeguard our aquifer from more than another pipeline? Or will this energy and concern pass? We can't let it!

Now is the time to leverage that energy. The Groundwater Foundation wants to do it in the way that we have always done it – by recognizing the commendable efforts of individuals and communities that are working tirelessly behind the scenes to ensure groundwater is clean and available for future generations. The Groundwater Foundation does not subscribe to scare tactics. We recognize the need for solutions that take into consideration our evolving society and our environment and know the challenges that face our water resources are not caused by any one entity or industry but rather by all of us in many different ways. As such, The Groundwater Foundation believes that each of us who benefits from the bounty of the resource is responsible for protecting and conserving it and collectively these individual actions will make a difference. Not only do we believe this, we have witnessed it.

Let's look at a community that has had to deal with both nitrates and the first Keystone TransCanada pipeline that was built in 2008 – Seward, Nebraska. Seward relies 100 percent on groundwater for its drinking water and, like many communities, had exceeded the maximum contaminant limit for nitrates. After researching various options, the community installed a multimillion dollar water treatment plant. The pipeline was constructed three-quarters of a mile upgradient of a city wellfield, meaning that a leak from the pipeline could potentially be transported into the city's water.

Seward benefits from an active Groundwater Guardian team, whose mission is to educate the community about their source of drinking water and to involve the community in protection efforts. The Groundwater Guardian team not only revised their wellhead protection plan, they put it into action by implementing a monitoring system for the wellfield. In fact, the USGS is monitoring the situation by verifying the direction of the groundwater flow and estimating the depth of the aquifer, sampling wells in the vicinity of the well field for nutrients and volatile organic compounds and conducting passive soil sampling. The technology developed for this project is designed to provide early detection of leaks and potentially can be used in other areas where drinking water could be at risk. For more information on the USGS project, visit http://ne.water.usgs.gov/projects/sewardpipeline.html.

What Next?

The Groundwater Foundation won't tell you whether you should be for or against the pipeline or development of alternative sources of energy. That is not our role. Our role is twofold: to provide access to reliable information that will assist you in making an educated decision. In fact, it is exactly this purpose of The Groundwater Foundation that attracted me to the position I hold now. People often ask, "Why is an art historian, trained in museum management, running The Groundwater Foundation? Where is that connection?" It lies in conveying information to assist in making an educated decision. A museum curator should not attempt to convince you one artistic era is more important than another. They should provide relevant information and an as accurate presentation as possible for you to make your own decision. This is exactly what we do, but instead of art, it's groundwater and the issues that surround it.

There is another connection. A huge component of museum management is protection and conservation of the artwork. Ironically, the worst thing for protecting and conserving art is putting it on display, which brings me to the second role of The Groundwater Foundation: to involve individuals and communities in water conservation and protection. Obviously not using water would be the most effective way to conserve it, but it's not that simple. The solution lies in finding the common ground between use and conservation/protection (just like displaying and conserving art). As such, we are always looking for ways to help people adopt behaviors to conserve water and to be smarter about their personal use, and help them understand that water is an integral part in every aspect of our lives. Once that connection is made, the steps we can take to do our part can be identified and adopted. Then we must celebrate our successes, showing how collectively our actions do have an impact.

Groundwater truly is the unsung hero—it has been, until recently, the epitome of "out of sight, out of mind." So, we need to keep groundwater in the forefront of our conversations, in the forefront of the decisions we are making, and not just in regard to the pipeline. While we recognize it is not the only consideration and topic to be discussed, we have to ensure it has a place at the table. We need to remember that we rely on groundwater for sustaining life and for our livelihood, and that groundwater relies on us. Let's Keep It Clean!

What You Can Do to Take Action

- Get your community involved as a Groundwater Guardian.
- Get sites in your community designated as Green Sites.
- Educate local youth about groundwater.
- Visit www.groundwater.org to learn more about these programs and much more!

References:

1. Unesco, Zaporozec, A., (2002), Groundwater Contamination Inventory, IHP-VI, Series on Groundwater No. 2, p. 25.

Editor's note: This article was previously published in the December 2011 issue of Prairie Fire. Visit www.prairiefirenewspaper.com.

Clean Earth, Clean Water...Take Your Pick!

By C.F. 'Chubb' Michaud, CWS-VI

"Ashes to ashes, dust to dust." We are all familiar with this oft-used phrase from the Book of Common Prayer (based on Genesis 3:19). Somehow, the author of these words had a unique understanding of the Laws of Conservation of Mass and Energy that wouldn't be discovered for more than a thousand years. Man cannot create matter or energy from scratch. He can only change its form. Likewise, he can never destroy matter or energy. All the molecules will remain, albeit in a different form of the exact same elements.

It All Gets Recycled

Take as an example the simple tree. It takes carbon dioxide (CO_2) from the air, combines it with water (H_2O) and through the miracle of photosynthesis (energy from the sun), releases oxygen (O_2) and creates cellulose ($C_{12}H_{22}O_{11}$), the stuff from which plants are made. We call it a carbohydrate. Starches and sugars are also carbohydrates and they all share the exact same chemical formula as cellulose. If we eat carbohydrates as a food source or burn the wood from that tree as a source of fuel, we recombine the carbohydrate with O_2 from the air and send the CO_2 and H_2O back to nature while releasing the original energy of the sun as heat. Nothing has been gained. Nothing has been lost. That's the Law.

Water is a great cleanser. We use it to wash our clothes, our dishes and ourselves. Mother Nature uses it to scour both land and sky. During the process, however, water can become contaminated.

Atmospheric moisture will condense on tiny dust particles before falling as rain or snow, and it cleanses the atmosphere of built-up gases (primarily CO_2) in addition to oxides of sulfur and nitrogen (also acid formers) and other debris. "Pure as rain" is a bit of a misrepresentation. Rain is actually a dilute acid at a pH of around 5.5 and often containing up to 50 ppm of total dissolved solids (TDS) including calcium, magnesium, sodium, sulfate, chloride and silica (which is leached from dust particles), as well as bicarbonate and CO_2. You have probably noticed that when rain falls on your freshly washed and waxed car, it leaves spots when it evaporates. After a few days of rain, the TDS drops to around 5 ppm, which is mostly as carbonic acid (H_2CO_3)—the combination of CO_2 and H_2O.

Most precipitation runs over the surface and collects in rivers, streams, ponds and lakes, and is known as surface water. Some soaks in and becomes well or spring water, also known as groundwater. Excess CO_2 tends to evaporate from surface containments so the water is closer to neutral in pH, generally lower in TDS, somewhat higher in dissolved oxygen, and typically iron free with low hardness. Groundwater, on the other hand, is neutralized by the soil, so is typically higher in TDS, hardness and whatever else is available from the soil. That's the part that should have you concerned.

Table 1.[1]
Major elements in the Earth's crust

Element	Symbol	Percent by Volume	Cumulative percent
oxygen	O	46.0	46.0
silicon	Si	27.2	74.32
aluminum	Al	8.13	82.45
iron	FE	5.00	87.45
calcium	CA	3.63	91.08
sodium	NA	2.83	93.91
potassium	K	2.59	96.50
magnesium	Mg	2.09	98.59
titanium	TI	0.44	99.03
hydrogen	H	0.14	99.17
phosphorous	P	0.12	99.29
manganese	Mn	0.10	99.39
fluorine	F	0.08	99.47
sulfur	S	0.05	99.52
chlorine	CL	0.05	99.57
carbon	C	0.03	99.60

Earth's crust—the part of the planet on which we live—is 20 to 30 miles (30 to 50 km) thick but only makes up less than one percent of the Earth's volume. It is composed primarily of metal and non-metal oxides (Table 1).

Metal oxides will form bases in water (Reaction 1), while non-metals tend to form acids (Reaction 2). These acids and bases further react to form other salts and water (Reaction 3). It is fortunate that the oxides (silica, aluminum and iron constitute nearly 85 percent) making up the surface of the Earth are sparingly soluble in water. Otherwise, we would all have fins. However, given a time span measured in hundreds of millions of years and the acidic nature of precipitation, elements are slowly leached from the crust and become part of the groundwater.

Reaction 1: $CaO + H_2O \rightarrow Ca(OH)_2$

metal oxides and water produce bases

Reaction 2: $CO_2 + H_2O \rightarrow H_2CO_3$

non-metal oxides and water produce acids

Reaction 3: $Ca(OH)_2 + H_2CO_3 \rightarrow Ca(HCO_3)2 + H_2O$

base plus acid produces salt plus water

The elements listed in Table 1 make up 99.6 percent of the bulk of Earth's surface. It is what's in the other 0.4 percent that gives us concern. 0.4 percent is 4,000 ppm and many of the other components of the Earth's crust make-up are toxic at only a few parts per billion!

Just Because It Doesn't Show on the Water Analysis Doesn't Mean It Isn't There

When we review the list of common ions found in water, it includes calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe), aluminum (Al), bicarbonate (HCO_3), chloride (Cl), sulfate (SO_4) and silica (SiO_2). Given the composition of the Earth's crust (Table 1), we can readily confirm the leaching of inorganic minerals into groundwater.

When we work on rating an ion exchange system, the components listed in Table 1 are often sufficient to get an accurate picture. After all, ion exchange doesn't really care who its partner is. Each ionic equivalent gets to occupy the same amount of space and an analysis that covers 99.6 percent is plenty good enough. Often, the trace elements (those making up the other 0.4 percent) aren't even listed. The ionic contribution of arsenic, lead, uranium and cadmium, for instance, may be less than 0.1 ppm (100 ppb). Even so, that water would be considered a toxic soup. It is the presence of

those trace elements that really determines whether a given water source is potable or toxic. So, where do these contaminants come from?

Why Do You Think They Call It Dirt?

Not only are all 90 of the naturally occurring elements found in *The Periodic Table* found in the Earth's crust (Figure 1), but all 90 can also be found in your water supply. Many are below the level of detection, but they are here. Many are considered toxic and we would call them contaminants. Much of the toxic element levels found in soil and groundwater are anthropogenic—a fancy word meaning 'caused by man'.

Of the 16 elements listed in Table 1 and making up 99.6 percent of the Earth's crust, only one (fluorine—usually present as calcium fluoride) is currently regulated on the US EPA's list of (primary) potentially harmful inorganic chemicals. The US EPA secondary regulations list includes fluorine, aluminum, iron, manganese, sulfur (sulfate) and chlorine (chloride) among the common rock-forming elements. For the most part, rocks are not very soluble in water, even acidic water. While we often experience treatable levels of naturally occurring arsenic, fluoride and uranium, it is unusual to find treatable levels of naturally occurring lead, cadmium, copper, zinc, selenium, molybdenum, antimony, chromium and others on the US EPA's list. That's because Mother Nature has had millions of years to clean up loose ends and most things that will dissolve are happily in equilibriums that are below the maximum contaminant levels (MCLs) for those elements (Table 2). Had things not happened that way, we might not be here. And, the way things are going, we are getting a second chance to wipe out mankind through carelessness.

Soil Contamination Leads to Water Contamination

Contrary to common belief, there is no such thing as pure water or clean dirt. All waters are simply dilute salts of various metals and all soil contains trace elemental metallic compounds. Ever since the invention of agriculture, man has been tweaking the composition of soil to improve his lot. Some of the tweaks are rather harmless, such as the addition of ammonium salt as a nitrogen source. Some are non-issues, such as the addition of calcium sulfate (gypsum) for pH control or sodium salt (NaCl) for moisture control. Others are not so friendly, such as arsenic, lead and fluoride-based pesticides.

The two biggest contributors to excessive levels of regulated elements in soil and water are: humans. We have met the enemy and it is us! While many trace metal contaminants can occur naturally, they are generally found at levels below the MCL. Over many years, through both neglect and ignorance, industry has used the back forty as a dumping ground and applied pesticides and fertilizers with no concern as to where they might end up. Smokestacks spewed millions of tons of arsenic into the air only to have it end up in the soil, and the water. In the 1930s, California sprayed lead arsenate on orchards at a rate of 260 lbs. of active ingredient per acre (US Department of Agriculture). That works out to over 100 ppm in the top six inches of soil per season. Five decades of tetraethyl lead (TEL) as an antiknock compound in gasoline has deposited millions of tons of lead into the atmosphere and onto the ground. In 1979 alone, auto exhausts released 208.1 million pounds of lead into the air in the US. Lead from auto emissions is carried over 50 miles and distributed widely by wind.

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Figure 1. Abundance of the elements in the Earth's crust

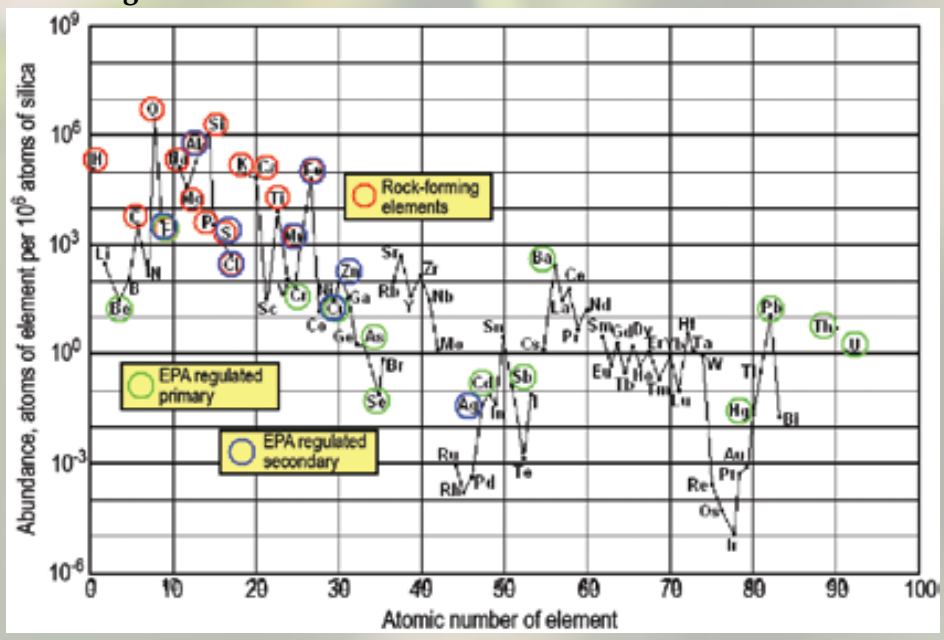

Table 2.
US EPA primary inorganic drinking water contaminants

Contaminant	MCL (mg/L)	Sources of contaminant
chlorine (Cl_2)	4.0	water additive for control of mircobes
antimony (Sb)	0.006	improper industrial discharge
arsenic (As)	0.010	natural erosion and run off from farming, pesticides, wood treating
barium (Ba)	0.004	natural erosion, burning of coal, metal refining
beryllium (Be)	0.004	burning of coal, metal refining, industrial discharge
cadmium (Cd)	0.005	natural erosion, runoff, corrosion of galvanized iron
chromium (Cr)	0.1	natural erosion, steel manufacture, plating waste
copper (Cu)	1.3 AL*	natural erosion, corrosion of copper plumbing, electronics waste
fluoride (F)	4.0	natural erosion, water additive, discharge aluminum manufacture
lead)Pb)	0.015 AL*	natural erosion, corrosion of household plumbing, leaded fuel
mercury (HG)	0.002	natural erosion, runoff from industrial, agriculture, and landfills
nitrate (NO_3 as N)	10	natural erosion, fertilizer runoff, sewage and septic, animal waste
nitrate (NO_2 as N)	1	leaching from agriculture, septic, sewage, feed lot animal waste
selenium (Se)	0.05	natural erosion, oil refineries, mine drainage waste
thallium (Th)	0.002	mining waste, electronics, glas0.05s and drug factory discharge
radium (Ra)	5 pCi/L	natural erosion
uranium (U)	0.03	natural erosion

*AL = action level (also requires process to reduce occurrence)

Pick, *continued from page 7*

Arsenic is contained in all soils and all water sources. Irrigation water is, therefore, an additional source of arsenic because when that water evaporates, it leaves the arsenic behind. Irrigation can deposit about 0.1 ppm per year of additional arsenic in soil. In fact, there is more of a contribution to soil contamination from irrigation than from fertilizer.

Once in the soil and water, contaminants can be taken up by plants. The driving force behind the banning of TEL from gasoline was concerns over the continued build up of lead in soil and agricultural produce. Lead is still used in fuel for aircraft and off-road vehicles. Arsenic is still used in pesticides and wood preservation. Add to this the use of fluoride in pesticides and other agricultural sprays (plus the questionable practice of adding fluoride to the drinking water supply) and we have a persistent problem and ongoing need for water purification for years to come. Dental fluorosis is on the rise even in areas that do not fluoridate their water supplies because the extensive use in pesticides and its presence in irrigation water has resulted in excessive fluoride intake just from food.[2]

In general, the higher the level of contamination in the soil, the higher the likelihood of that contaminant showing up in groundwater. Contaminated soil leads to contaminated water. The containment of toxic substances deep underground (so called proper disposal) is but a temporary out-of-sight-out-of-mind fix. True to the parable, these substances will, one day, again join the soil and water from whence they came.

There is both a good side and a bad side to this fact. On the plus side is that should the source of contamination be halted, Mother Nature will eventually clean up the soil by having a constantly refreshed water supply pass through it. The negative side is that the movement of groundwater will move contaminants into other areas that may be more in the mainstream of urban living. This will lead to a shortage of cheap water and necessitate costly municipal and residential treatment.

The Nature of Dirt

Not apparent from the general composition of the Earth's crust is what we might call the active ingredient in soil. Chemically, it is a sodium aluminosilicate or zeolite. There are more than fifty identified zeolites that occur naturally[3] and they vary widely in composition. They all have certain properties in common—they are all ion exchangers. Mined zeolites are typically in the sodium or potassium form (cation) and the Na^{+} and K^{+} ions are held rather loosely. This allows them to exchange with ions of higher charge—just like softeners. This unique chemistry of soil allows some contaminants to be far less mobile than others. One means of treating Cr^{+6} (an anion) is to chemically (or through the use of microbes) reduce it to Cr^{+3} (a cation), which is then immobilized by the soil. The same happens with lead, cadmium, copper, iron, manganese and zinc. Anionic metals (i.e., selenium, molybdenum, antimony, uranium, vanadium) are more mobile and show up downstream of the actual point of introduction.

And Your Point Is?

There's a reason your mother told you not to eat dirt! It can be pretty nasty. Soil contamination can occur through the natural erosion of rock but is primarily caused by centuries of human neglect and carelessness. Soil contamination is, in and of itself, problematic because it provides a source of heavy metals that can be taken up by plants. That puts those contaminants directly into the food chain. In addition, soil contamination leads to water contamination. This, in turn, leads to contaminated livestock, fish and fowl, all of which pass the contaminants on up the food chain and back to humans (think mercury and swordfish). Is this the origin of the expression "What goes around, comes around?" The problem is that a lot of people who are not responsible for the actions suffer the consequences.

Conclusions

Although the oceans are the eventual repository of all things discarded, the soil is the staging area. Atmospheric precipitation is acidic and as it passes through Earth's strata, it takes a little bit of everything it touches along with it (including those corrosion-proof burial containers). While nature provides a cleansing action, water (and the aquifer) become contaminated.

Many common contaminants such as lead, arsenic and fluoride are accumulated by the body and even though not at toxic levels now, they may become so over time. For many of these contaminants, the only safe level for drinking water is zero. In addition, water is not your only source of these contaminants. Many are also found in the food we eat. Even organically grown produce does not guarantee chemical-free because these contaminants are everywhere. Wastes that are dumped upon and buried in the ground do not stay put.

If you, as a water treatment professional, are intent on protecting the consumer with safe drinking water, you must also take the responsibility of approaching the customer with a good water analysis. Single digit ppb levels of heavy metals can be significant. Otherwise, you'd be guessing. We all know what's out there and it does no good to bury our heads in sand (sand = soil = dirt). The water treatment industry has unlimited potential to both make a living and to help people live.

References

1. www.wikipedia.com, en.wikipedia.org/wiki/crust_geology.
2. Michaud, C.F., Fluoride–The Good, The Bad and The Ugly, WC&P, February, 2010.
3. International Zeolite Association, Database of Zeolite Structure.

Editor's Note: The views represented in this article are those of the author and do not represent The Groundwater Foundation staff, Board of Directors, or Technical Advisory Committee.

You are here-X

To put the enormity of the planet and the part we occupy into perspective, let's take a basketball and a can of spray paint. Our basketball is about 10 inches (25 cm) in diameter and if we give it a good coat of spray paint, we end up with about 10 mils (0.25mm) of paint (about 1/1000ths the diameter of the ball). Everything that has ever walked upon, swam through, burrowed under or flown over this planet (not counting ETs) since Day One has done so within the relative confines of that paint film. The total crust of the Earth is thinner than the rubber making up the cover of the ball. So we occupy a very small part of this rock, but at least it's the exciting part.

Teaching Youth to Think Blue

Orange County Water Festival Educates Thousands

By Gina DePinto, Orange County Water District, California Groundwater Guardian Team

For almost two decades, the Orange County Water District (OCWD) in Fountain Valley, California, its Groundwater Guardian Team and Disneyland Resort has hosted the largest water education festival of its kind educating more than 92,000 Orange County students and their teachers about water and the environment. From laboratory experiments to water relays, Orange County children have been learning first-hand over the past 15 years about water and the environment, and how they can conserve our limited natural resources.

The 16th annual Children's Water Education Festival will be held March 28-29, 2012 at the Richard Nixon Presidential Library and Museum in Yorba Linda, California. The mission of the Festival is to educate students about water-related and conservation issues that correspond to California Science Standards. This year's Festival will reach about 6,000, 3rd through 5th grade public, private, charter and home school students and their teachers who will learn about topics like water recycling, groundwater supplies, conservation, water chemistry, the water cycle and watersheds, climate change, natural resources, waste management and water rights.

"Being a part of this event allows us to strengthen our commitment to conservation by teaching students to think differently about how they use water and inspiring them to make a difference in their communities," said Frank Dela Vara, Director of Environmental Affairs for the Disneyland Resort, a Festival sponsor for 16 years.

National Geographic Emerging Explorers Are Featured Presenters

At the 2012 Festival, students will be treated to presentations from two National Geographic Emerging Explorers. Kevin P. Hand, Ph.D., a planetary scientist/astrobiologist at NASA's Jet Propulsion Laboratory (JPL), will share his work at NASA/JPL seeking to find evidence of life beyond Earth by following the water. He will talk about the conditions that support life on Earth and why scientists believe life could exist in the vast sub-surface ocean of Europa, Jupiter's fourth largest moon. Zeb Hogan, Ph.D., an aquatic ecologist, will teach the students about his work identifying and protecting the world's largest freshwater fish species and the ecosystems that support these "mega fish."

The Festival is provided at no cost to schools, making public and private financial support crucial to the success of this educational event and its continued growth. Conducting a Festival of this size requires more than 400 volunteers, staff and presenters, as well as in-kind and monetary donations. Volunteers help with a range of activities, from staffing registration tables to directing students to their next activity. In addition, presenters are needed to staff the Festival's interactive booths. Many of the activities are taught by industry experts from the community.

Teachers return to the Festival year after year with their classes to engage in this unique educational opportunity. The Festival is a fun, environmental education program designed to teach students about the interdependence of water, soil, plants, trees, animals and humans.

Change is generational; through the Children's Water Education Festival, OCWD is able to teach youth to think "blue" and make a difference in protecting our water resources for today, tomorrow and for future generations.

About OCWD

OCWD manages the large groundwater basin that underlies north and central Orange County that provides most of the water for about 2.4 million citizens. OCWD also operates the world renowned Groundwater Replenishment System and has been a Groundwater Guardian Community since 1995.

OCWD is committed to enhancing Orange County's groundwater quality and reliability in an environmentally friendly manner. With more than 78 years of prudent planning and careful investment, OCWD has doubled the sustainable yield of the groundwater basin. OCWD is a special district established by the California State Legislature in 1933 and governed by a 10-member board of directors.

Visit http://www.ocwd.com/ and www.gwrsystem.com for information.

News From The Foundation

Groundwater Foundation Board Welcomes New Members

The Groundwater Foundation is happy to announce the addition of three new members to its Board of Directors. Ann Bleed, Cathy Lotzer, and Lee Orton were elected to the Groundwater Foundation Board of Directors at its December meeting. "The Groundwater Foundation is very fortunate to gain the expertise and talents of these great individuals," said Groundwater Foundation President Jane Griffin. "We look forward to learning and benefitting from their involvement."

Ann Bleed of Lincoln, Nebraska served as the Director of the Nebraska Department of Natural Resources, facilitating solutions to issues involving water management and allocation, conjunctive management of surface water and ground water, transboundary allocation, and integrated and adaptive resources management. Ann currently provides facilitation and consulting services on water allocation issues and teaches a water law course at the University of Nebraska Law School. Ann is a registered professional engineer in Nebraska.

Cathy Lotzer is the Human Resources Manager at Marshfield Utilities in Marshfield, Wisconsin. She has been an employee of the Marshfield Utilities for almost 30 years, serving as the coordinator of the Marshfield Groundwater Guardian team which has been designated each year since 1997. Cathy was also a member of the Groundwater Guardian Council for six years serving as vice chair in 2007/2008. Cathy has a background in human resources, community service, leadership, creative and innovative project development, and local water utilities.

Lee Orton, also of Lincoln, Nebraska has been actively involved in water issues in the State of Nebraska since 1969. In addition to practicing law focused on natural resources and environmental issues in his own law firm, Lee also serves as the executive director of the Nebraska Well Drillers Association, the Nebraska State Irrigation Association, and the Nebraska On-site Waste Water Association. Lee brings a myriad of experiences to The Groundwater Foundation including water law and policy, nonprofit management, water well management, groundwater science, and agriculture.

Others serving on The Groundwater Foundation Board of Directors include: Warren Arganbright, Arganbright Law Office, Valentine, NE; James Beaumont, Eustance & Horowitz, P.C., Walden, NY; James Burks, Senninger Irrigation, Inc., Clermont, FL; Chandler Mazour, Monsanto, Gothenburg, NE; E. Robert Meaney, Valmont Industries, Inc., Omaha, NE; Steve Seglin (ex-officio), Crosby, Guenzel LLP, Lincoln, NE; Thomas Spears, Author, Ashland, NE.

Members Help Recharge the Aquifer

The Groundwater Foundation would like to extend thanks to our loyal and generous members for helping us "recharge the aquifer" and support our mission!

We've filled our aquifer, but still need your help. If you haven't become a member yet, join today and help the Foundation to:

- Educate thousands of children about groundwater and help them to understand how they even at a very young age can do their part to protect it.
- Share groundwater awareness messages with hundreds of thousands of people through radio and TV PSAs and movie trailers.
- Support hundreds of communities and businesses working to protect groundwater locally.
- Reach new audiences with groundwater messages through our newsletters, website, blog, Facebook, and Twitter.

Groundwater is important, and we all must do our part to protect it. Act today by becoming a member of The Groundwater Foundation and help support our mission of educating people and inspiring action to ensure sustainable, clean groundwater for future generations. Visit www.groundwater.org and click on the "Become a Member" button or call 1-800-858-4844.

Get Ready for Spring with New Catalog Products

The Groundwater Foundation has new and fun catalog products, just in time for spring festivals and education events!

Visit our online store at http://www.groundwater.org/shop/default.asp and check out the Mood Pencils and Seed Packets.

Are you in the mood to protect groundwater? Of course you are! Our newest #2-lead pencil is a mood pencil that encourages everyone to help keep groundwater clean. Kids and adults alike will enjoy watching these pencils change color in seconds! They're made from an environmentally-friendly synthetic wood alternative and include the "Let's Keep It Clean!" message. Pencils start at just $.50 each.

You can also beautify your yard by just adding groundwater to our wildflower seed packet! Even beginning gardeners can achieve a beautiful planting as the wildflowers need little care and are suitable for most growing conditions. The back of the packet includes the message "Groundwater is the water we drink, the water that grows our food and these flowers." Packets are made of recycled paper and printed with soy-based ink. They include a mixture of Bachelor Button, Baby's Breath, Annual Blue Flax, Shirley Poppy, and Candytuft and are just $.75 each.

Stock up now! Order online or call 1-800-858-4844.

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