In-situ arsenic removal during groundwater recharge in Antelope Valley

Summary

Naturally occurring arsenic commonly exceeds the U.S. Environmental Protection Agency's drinking water standard of 10 micrograms per liter (µg/L) in groundwater throughout much of the southwestern United States. Arsenic occurs naturally in rocks and soil, water, air, and plants and animals. It can be further released into the environment through natural activities such as volcanic action, erosion of rocks and forest fires, or through human actions. Arsenic has been linked to cause cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate. Non-cancerous health effects of arsenic can include thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in hands and feet, partial paralysis, and blindness.

Beginning in October 2011, the Los Angeles County Department of Public Works, Waterworks Division (Waterworks), partnered with the United States Geological Survey and the Antelope Valley East Kern Water Agency to determine the effectiveness and sustainability of natural soil to reduce high arsenic levels in water. Waterworks conducted a pilot-scale study in Antelope Valley, California, where high-arsenic groundwater was pumped from the deep aquifer and discharged into a half-acre pond. The water then passed through a 265 foot thick unsaturated zone and experienced a reduction in arsenic levels before recharging the shallow aquifer. The shallow and deep aquifers are separated by a solid clay layer. That clay layer contains arsenic which leaches into the deep aquifer. The infiltrated water would serve as a source of recharge to the shallow aquifer where it could later be pumped for public supply due to its reduced arsenic concentration.

Arsenic concentrations in the infiltrated water decreased from 30 µg/L to 2 µg/L, primarily as a result of sorption to oxides on mineral grains within the unsaturated zone. As the water infiltrated the unsaturated zone to the shallow aquifer, the arsenic in this water was attached onto iron, manganese, and aluminum naturally found within the ground. Rocks and soil from the unsaturated zone were tested to describe the physical and chemical factors that control this arsenic sorption. The study found that most sorption occurred very quickly within the upper 26 feet of the unsaturated zone.

Waterworks operates 32 wells containing arsenic above the drinking water standard, each producing from 500 to 1000 gallons per minute. The majority of the water from these wells is unusable without treatment or blending. The potential annual amount of water available for in-situ treatment from these wells is 36,000 acre-feet. A full-scale in-situ treatment system would handle the full production capacity of these wells.

Benefits to Environmental Resources

Waterworks relies on groundwater and imported water supplies from the State Water Project (SWP) to meet water demands. However, SWP supplies are highly variable and subject to a variety of delivery restrictions. Southern California's imported SWP water supplies rely primarily on rainfall and snowpack levels in the Sierra Nevada Mountains, which can change dramatically from year to year. The success of this project would increase the groundwater supply available, reducing the variability and potential shortfalls in water supply. In addition, an increase in the available usable groundwater supply would reduce the demand of SWP, resulting in an increase in water available for habitat preservation in the San Joaquin Delta.

Conventional Reverse Osmosis treatment to remove arsenic requires an extensive amount of energy to maintain high water pressures through the treatment system. Comparatively, the only energy required for in-situ arsenic removal is that necessary to pump the water from the deep aquifer, which would also need to be done for conventional treatments, and then again from the shallow aquifer. Thus, the significant energy savings provides benefit to the environment by producing less Greenhouse Gas Emissions.

Contribution to wellbeing of DPW employees and the County Community

Water shortage is a regional issue in Los Angeles County due to limited supply availability, which is why it is vital to collaborate to resolve the resource issue. The success of the technology will provide Antelope Valley residents and businesses with an additional source of drinking water, a resource that is in high demand because of the over-drafting of aquifers throughout the state. It could also prove beneficial for millions of people across the western United States where arsenic concentrations in groundwater exceed the Federal water quality standard. The project will greatly contribute to enriching community life by providing clean and healthy drinking water in a sustainable manner.

Economical contribution

The Project presents an approach to lower the financial cost of arsenic treatment so that it is an attractive option relative to other alternatives such as reverse osmosis or ion-exchange. Neglecting the substantial investment in equipment and engineering design, the cost of arsenic treatment using commercially available sorptive media is between $600 and $800 dollars per acre-foot. The cost of treating water to remove arsenic using the proposed natural and sustainable *in-situ* approach is essentially the cost of pumping the water. The pumping cost in the Antelope Valley is approximately $150 per acre-foot. This data suggest that *in-situ* arsenic removal will result in a cost savings of $45 million to $65 million over the life of the site compared to removal using commercially available sorptive media.