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Advanced Treatment for Groundwater:

Treating Low-Quality Groundwater for Municipal Use

High quality groundwater that can be pumped and disinfected for municipal use is becoming a scarce commodity. Naturally occurring and man-made contaminants are requiring many suppliers to install additional treatment methods to meet stringent federal and state requirements. Many streamside alluvial aquifers are recharged with surface waters containing objectionable levels of either sulfates or chlorides. These contaminants are not removed easily without advanced treatment.

Basic treatment of groundwater consists of adding chlorine for disinfection and polyphosphates to sequester iron and manganese. This treatment works well if the source water is within Maximum Contaminant Levels (MCLs) issued by the U.S. Environmental Protection Agency (EPA). These MCLs were issued for chemical compounds that can have serious health effects and may require treatment to minimize their level in the water supply. In addition to MCLs, the EPA has issued Secondary MCLs (SMCLs) for compounds that create aesthetic concerns. These include hardness-causing compounds, sulfates and chlorides. For many suppliers, the secondary MCLs are very important since they affect the way the water tastes and how their consumers react to the water quality.

Advanced treatment of groundwater often is needed to reduce contaminant levels to below the MCLs. These treatments may include aeration, lime softening, ion exchange (IX), electrodialysis reversal (EDR) or reverse osmosis (RO). Each of these treatment schemes has advantages and disadvantages. Aeration removes dissolved gasses such as radon and volatile compounds. Lime softening removes hardness and some of the metallic MCLs. Ion exchange systems can be tailored to remove most MCLs, and EDR and RO can remove virtually all compounds from the water. The task of the designer is to determine the treatment that is most appropriate and cost-effective for the consumer.

The disposal of waste products from the water treatment process is critical. Whenever contaminants are removed from the source water, they must be disposed of in a manner that is legally and socially acceptable. Dissolved gasses are released into the atmosphere and are regulated through dispersion models that show

Industrial strength reverse osmosis systems can remove virtually all contaminants from a groundwater source.

the direction and concentration of the airborne plume. Lime softening results in a precipitated sludge that can be reused as a soil amendment, injected into cement kilns or coal-fired power plants or disposed of in landfills. IX results in a highly concentrated brine solution that contains high levels of the contaminants being removed plus the chemical used to recharge the exchange resin. EDR and RO wastes contain all of the original components from the source water but in a highly concentrated solution.

The IX, EDR and RO processes typically return their waste products back into a nearby stream or river. This is allowed if the discharge meets the state's water quality discharge criteria and an NPDES permit is obtained. Therefore, this process ensures that the environment is not damaged by the discharge. If the water quality standards cannot be achieved due to either low streamflows or high levels of contaminants in the discharge water, then alternative methods must be used to dispose of wastes. In the past, large evaporative ponds were used to store and concentrate waste byproducts. However, many of the ponds leaked, causing contamination of the local aquifer, or became toxic landing zones for waterfowl.

A more acceptable alternative for disposal is deep well injection. This process discharges the waste products into a deep nonpotable zone that is sealed off from usable water bearing zones. The process permanently removes the contaminants and the carrier water from the ecosystem. For this reason, the waste stream is concentrated to the highest degree possible.

Current Study

Burns and McDonnell presently is studying the use of RO for treatment of poor-quality groundwater along the Arkansas River. This river receives much of its flow from irrigation runoff as it passes through Colorado. Many of the chemicals that exist in the soil such as chlorides and sulfates are leached into the water and further concentrated through evaporation.

When the Arkansas River reaches the Kansas border, the level of sulfates can reach 2,600 mg/L. This level is more than 10 times the secondary MCL. This water recharges the alluvial aquifers along the river. Irrigation or municipal wells located near the river can draw plumes of this surface water further into the aquifers and contaminate existing higher-quality groundwater. Even deeper zones of good quality water can be contaminated through faults in the geologic formation or abandoned or improperly sealed water wells.

The groundwater being considered contains Total Dissolved Solids (TDS) in excess of 1,500 mg/L, sulfates in excess of 1,300 mg/L and chlorides in excess of 100 mg/L. This water meets the current EPA MCLs and by law could be supplied to consumers simply by adding a disinfectant. However, supplying this water would create extremely dissatisfied consumers due to the poor taste and the severe gastrointestinal effects of the sulfates.

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Reverse Osmosis

RO was selected as the optimal treatment method due to its ability to meet the current drinking water standards and for its modular construction. Modular construction allows treatment capacity to be installed for present needs, increases the ease of expansion and reduces both front end cost and consumer cost.

The individual RO treatment skids each will produce 650 gallons/minute and are self-contained. To facilitate installation, they are constructed at the factory to include all of the prefilters, high-pressure pumps, RO membranes and microprocessors on a single skid. When they arrive at the project site, all that is required is to connect the influent, effluent, waste lines and power lines. No significant infrastructure is required for each incremental plant expansion. This allows the water supplier to expend less front-end capital and to rely less on long-term growth projections.

The disposal of the waste stream from the RO units provides certain challenges. The concentration of sulfates exceeds 7,000 mg/L and, due to the poor quality of the receiving stream, the state water quality standards would be violated if these flows were discharged. Several alternative disposal methods were reviewed and deep well injection was selected due to its ability to accept these concentrated flows and its known upfront costs. To minimize the quantity of wastes being disposed of and to maximize the quantity of usable water, a "scavenger" RO skid is included to further process the waste stream.

The treated water from the RO units is exceptionally pure and contains low concentrations of chemical constituents. This makes it very corrosive to metallic pipes and plumbing. Before being distributed to the consumer, the water must have the pH adjusted and some alkalinity reintroduced. This is accomplished by blending the treated water with a portion of the raw water supply. This also gives the water some flavor and makes it more economical to treat. After blending, the water is pH adjusted a second time, disinfected and stored until needed by the consumers.

Summary

Groundwater sources that can be used for drinking water purposes are requiring increasing degrees of treatment to meet the requirements of both the regulating agencies and the consumer. Treatment types that only a few years ago were considered exotic are now routinely being used to remove contaminants from groundwater sources. Along with the treatment side, the handling of waste products requires the review of more options to find an acceptable method.

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