new technology for Groundwater Remediation

By Peter Meyers

Simulation program focuses on ionized substances removed by ion exchange resins

Ion exchange continues to gain popularity as a method for removing trace contaminants from groundwater and other effluent that must be treated prior to discharge. Generally speaking, these are fairly new and rapidly growing applications.

The number of contaminants added to the EPA's contaminant list continues to grow. As our ability to measure lower concentrations of all contaminants and then correlate them with health and production benefits improve, the maximum contaminant levels (MCLs) and purity requirements in all applications are becoming more stringent.

When trace contaminants are to be removed, it is not unusual to have two or more trace contaminants present that are simultaneously removed in a single resin bed. Before simulation technology, there was very little resin performance data available for these kinds of applications.

For some trace ions, the service run lengths of an ion exchange resin are enormous. In these cases, it is more practical to change out the exhausted resins for virgin resins instead of regenerating them. However, in cases where multiple trace contaminants are removed by a single resin bed, the throughput for each contaminant is likely to be different than for the others. In these cases, the resin must either be regenerated or changed out when leakage of the first contaminant reaches its limiting value. In other cases, a contaminant that is present at levels below discharge limits could be concentrated by the ion exchange resin and then released at excessive concentrations later in the exhaustion cycle.

Simulation Technology

The Mist-X simulation technology combines mass action and kinetic relationships to simulate exhaustion and regeneration cycles of an ion exchange resin. The simulation program is designed to deal directly with ionized substances removed by ion exchange resins. It calculates the exhaustion profile for each ion in each portion of the water and the resin bed as the water or liquid passes through the resin.

Variations in operating conditions can be studied quickly and efficiently as Mist-X provides a calculated effluent history for every ionic substance passing through the resin bed. The results are generally displayed graphically but can also be presented in tabular format. There is virtually no limit to the amount of ions, valences or number of exhaustion and regeneration cycles that can be studied.

The input requirements for a simulation are similar to any other request for process design, such as a full water analysis with the ions of interest and any competitor ions, plus effluent goals for each substance of interest including maximum allowable levels.

A partial list of common contaminants that are easily and simultaneously handled by the simulator include:

Common Anionic Contaminants

- Arsenate and arsenite;
- Uranium;
- Chromate;
- Perchlorate;
- Selenate and selenite;
- Phosphate (monobasic, dibasic and tribasic);
- Nitrite and nitrate;
- Molybdate;
- Vanadate;
- Borate; and
- Fluoride.

Common Cationic Contaminants

- Radium;
- Barium;
- Lead;
- Mercury; and
- Copper.

System designers need to know how the pH level of the treated water will vary throughout the service cycle of the resin to ensure that the treated water pH level falls within EPA guidelines. The simulation technology does this and can demonstrate the effect of alternate approaches such as variations in ionic forms of the starting resin.

Another way the technology can be used is to simulate a pilot plant. Hundreds of cycles of exhaustion followed by regeneration under varied regeneration doses and alternate regeneration methods can be trialed in a few minutes or hours, saving countless days, months or even years operating a pilot plant in the field.

Mist-X can show how many operating cycles it will take to react to changes in operation before returning to stable operation. It allows direct comparison of performance for changes in regenerant dose levels, bed height, flow rates, countercurrent versus cocurrent regeneration and endpoint termination criteria.

From the large number of potential groundwater analyses that might need to be treated, we have selected a few that illustrate the power of the simulations.

- NO_3 and ClO_4 by a gel Type I anion resin;
- As and NO_3 by a nitrate selective anion resin; and
- As, NO_3, ClO_4 and U by a gel Type I anion resin.

Case 1 - Multicycle nitrate removal system that also removes perchlorate.

An existing nitrate removal system is challenged to remove perchlorate in addition to nitrate. What will happen to perchlorate leakage over time? Will perchlorate build up on the resin, and if so, what concentration level will it eventually reach?

The answers can best be displayed graphically (Figure 1). Over the first few cycles, perchlorate leakage is close to zero; however, perchlorate is not completely removed from the resin each regeneration and gradually builds up to reach steady state operation at a higher concentration.

Case 2 - Is a nitrate selective resin the best choice when water also contains arsenic?

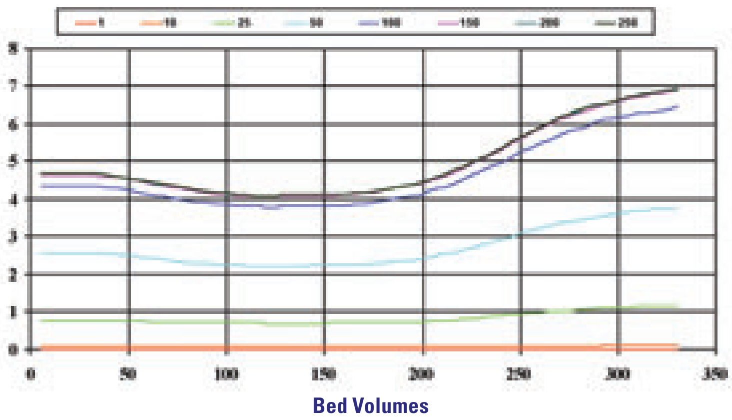
Perhaps not. A Type I anion resin such as SBG1 will not start to leak arsenic until well after nitrate breakthrough. A nitrate selective resin such as SIR-100-HP will dump arsenic back into the outlet at a concentration much higher than the inlet, long before nitrate leakage begins to rise.

Simulation technology easily provides information that can be used to make informed decisions about which type of resin is best for a particular application. For this water supply, a Type I anion resin provides as much or more throughput as a nitrate selective resin without arsenic dumping.

Case 3 - Simultaneous removal of uranium, perchlorate, nitrate and arsenic.

When many targeted contaminants

Figure 1. Nitrate Selective Strong Base Anion Resin
Perchlorate Leakage
Over 250 Cycles



are present, it is useful to know the effluent concentration of each contaminant and where the contaminant concentration peaks. In this example, it is useful to know that even though nitrate dumping does occur, neither nitrate nor arsenic ever exceed discharge limits.

There is essentially no limit to the number of ions that can be evaluated simultaneously by the simulator. This allows rapid analysis of even the most complex groundwater supplies.

Simulation technology can replace physical pilot plant studies, providing data in minutes that might otherwise take years. It can simulate cocurrent, countercurrent and homogenized bed regeneration techniques for as many cycles as desired, for exhaustion followed by regeneration to make such studies practical; show chromatographic peaking for multiple ions simultaneously; and predict complex changes in operating systems when inlet water compositions change, like switching supply sources on operating systems.

Models of ion exchange systems can be used as a tool in the process design of an ion exchange system and as a troubleshooting tool to examine behavior of systems already in operation. *wqp*

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