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Chemical Treatment and Ultrafiltration

Atomic Energy of Canada, Limited

Technology Description: The Atomic Energy of Canada, Limited (AECL) process uses chemical pretreatment and subsequent ultrafiltration to remove trace concentrations of dissolved metals from wastewater, contaminated groundwater, and leachate. The process provides both selective removal of metal contaminants and a volume-reduced waste stream amenable to further treatment.

In the process, a relatively high molecular weight polymer, generally a commercially available polyelectrolyte, is added to the wastewater to form large, selective metal-polymer complexes at desired pH and temperature conditions. The solution, containing enlarged metal-polymer complexes, is then processed through a cross-flow ultrafiltration membrane system that retains the complexes (retentate or concentrate), while allowing uncomplexed ions (such as calcium and/or sodium) to pass through the membrane with the filtered water (permeate). The permeate may be discharged or recycled, depending on the goals set for metal removal.

The field-scale unit is 5 feet wide by 7 feet long by 6 feet high. The skid-mounted system consists of (1) a bank of 5-micron cartridge prefilters, (2) a feed conditioning system with chemicals for pH adjustment and polyelectrolytes, (3) two banks of hollow-fiber ultrafilters, (4) a backflush system for cleaning the membrane unit, and (5) associated tanks and instrumentation. The two banks of filters provide a total membrane surface area of 390 square feet and a permeate rate of about 8 gallons per minute.

The wastewater is pH adjusted and fed through the prefilter for removal of suspended solids. The filtered wastewater is then routed to conditioning tanks where the metal-polyelectrolyte complexation occurs. The conditioned feed is then pumped to the ultrafilter assembly through a recirculation loop. This loop includes the membranes and provides the necessary contact time and turbulence for separation of the metal-polyelectrolyte complexes and other suspended and colloidal particles. The permeate stream, which can be discharged, may be continuously withdrawn, while the concentrate stream, containing most of the hazardous contaminants, is retained in the recirculation loop until the desired volume reduction is achieved. Figure 1 presents a schematic of the process.

Waste Applicability: The process can be used to treat wastewater contaminated with trace levels of toxic, heavy metals that arise from a variety of sources. Specific potential applications include removal of metals such as cadmium, lead, mercury,

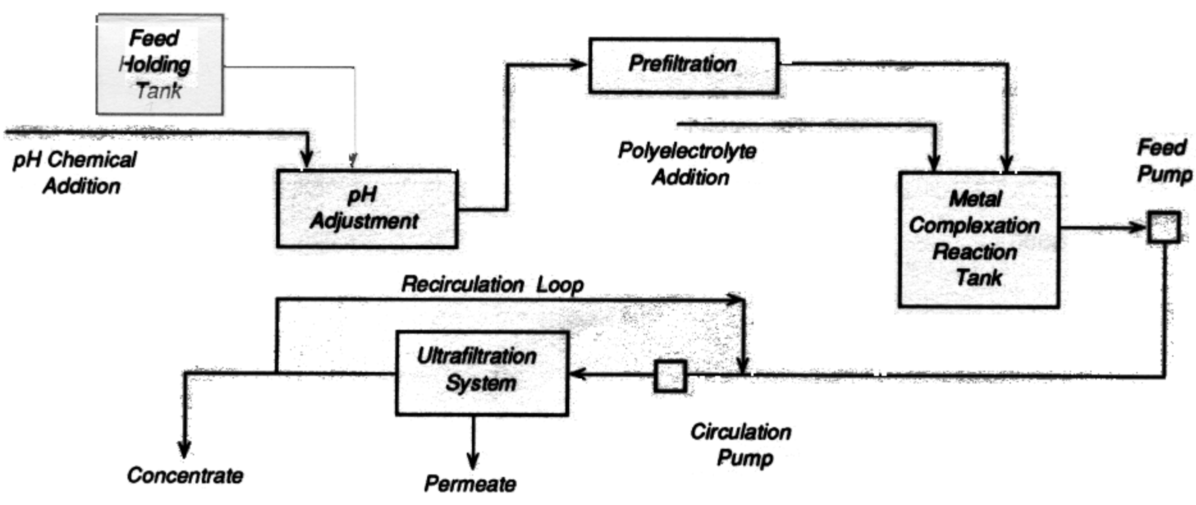

Figure 1. Chemical Pretreatment and Ultrafiltration Process.

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uranium, manganese, nickel, chromium, and silver. Dissolved metal concentrations amenable to treatment range from a few to tens of parts per million. In addition to dissolved metals, other inorganic and organic materials present as suspended or colloidal solids can also be removed. The sole residue generated by the process is the ultrafiltration concentrate - generally constituting 5% to 20% of the feed volume.

Test Results: Process testing was accomplished at bench-, pilot-, and field-scale. It was verified that the method provides the necessary metal ion size enlargement for ultrafiltration separation of metals, and that the permeate stream is essentially free of toxic metal contamination. In addition to metal-polyelectrolyte complexation, certain metals can be precipitated by pH adjustment to exploit the combined effects of complexation, precipitation, and free ion adsorption.

Bench-scale testing of the process with two membrane types and two polyelectrolytes indicated that cadmium, lead, and mercury can be removed at rates greater than 95%. Although a bit more susceptible to fouling, polysufone membranes are preferred over cellulose acetate membranes because of their greater permeation rates and ability to perform under a wide range of pH conditions.

Pilot-scale testing of the process yielded metal removal rates consistent with the bench-scale tests. The pilot unit, utilizing hollow-fiber membranes, operated at pressure differentials of 20 - 25 psig. It was noted that at this scale, a prefiltration step is critical to the operation of the hollow-fiber units in order to prevent membrane plugging. Further, the pilot-scale studies confirmed earlier results showing the need for a polyelectrolyte to total metal concentration ratio of about 3 to 10.

The field-scale unit provided separation efficiencies in excess of 90% for mercury, cadmium, and lead. It was shown that the presence of iron and sulfate ions in the feed, however, greatly influences metal removal efficiencies and can lead to poor results. The unit performed at less than anticipated efficiency when processing wastewater in the field, due in part to the ineffectiveness of the polyelectrolyte chosen, the high ionic strength of the waste feed, and the interference of large quantities of iron, calcium, and sulfate ions. Subsequent testing of the unit has shown that, with proper treatability studies, acceptable field performance can be obtained.

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