Constructed Wetlands Treatment System For Landfill Leachate In Cold Climates

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Background

Metro Waste Authority (MWA) in Des Moines, Iowa, USA is a quasi-governmental agency formed in 1969 to manage waste disposal from 17 central Iowa communities. The Metro Park East Landfill (MPE) receives an average of fifteen hundred tons per day of municipal solid waste and generates over five and a half million gallons of leachate annually. Prior to April 2000, leachate management was conducted by trucking the leachate to three area wastewater treatment plants at a cost of over $250,000 per year. MWA viewed trucking as a short-term solution and in the fall of 1997, retained the consulting team of Foth & Van Dyke and J. F. New and Associates to evaluate the potential of leachate treatment using constructed wetlands.

Design Considerations

The unlined landfill area of MPE had 31 leachate extraction wells in-place with another 9 extraction wells to be added in the future. Data from the ten most productive wells was used to develop an average leachate flow. That flow was used to predict the total leachate flow from the 40 extraction wells which would ultimately serve the unlined portion of the landfill. The lined landfill areas of MPE consisted of an 7.3-hectare clay lined area to the north that was in the process of being brought to final grade and final cover, and two 3.9-hectare composite lined cells to the south which were not yet in use. The United States Environmental Protection Agency's Hydrologic Evaluation of Landfill Performance (HELP) Model was used to estimate leachate generation in the lined landfill cells for a variety of conditions. These conditions included various waste depths and no cover, various waste depths with intermediate cover, and waste with final cover. Based on 15 model simulations, average and peak leachate flows of 64.6 cubic meters per day (m^3/d) and 74.2 m^3/d respectively, were developed. Laboratory data gathered from the previous 10 years of landfill operation was used to predict concentrations of a wide range of leachate constituents including heavy metals, trace elements and organic compounds. The data showed that a Biochemical Oxygen Demand (BOD_5) of 6,100 mg/l, and Total Kjeldahl Nitrogen (TKN) of 420 mg/l could be expected. The level of treatment that needed to be achieved was dictated by the state of Iowa in their Wastewater Facilities Design Standards, Chapter 21, Land Application of Treated Wastewater. Based on Chapter 21 requirements, estimated mass loadings and anticipated removal efficiencies, zinc was determined to be the limiting element. Based on allowable zinc accumulation, the life expectancy of the prairie disposal field was determined to be 29 years. Experience from other landfills using wetlands for leachate treatment was considered including Norwegian experience with wetland treatment at the Esval Landfill. Evaluation of these systems identified that adequate pretreatment and operational flexibility were most critical to successful performance of the wetlands.

Constructed Wetlands Treatment Facility

The first of its kind in Iowa, the facility includes an aerated lagoon, two storage lagoons, four constructed wetland treatment cells and a spray irrigation field consisting of a planted prairie of native species. During the growing season, the treated leachate is applied to the planted prairie using spray irrigation technology. During the winter, the pretreated leachate is either stored or recirculated through the wetland cells. The aerated lagoon uses two floating aerators to achieve iron precipitation and BOD removal. It is well documented that leachate quantity and quality is highly variable and difficult to predict, therefore the aerated lagoon was designed to accommodate up to two additional floating aerators should the strength of the leachate increase over time. A separate lagoon is provided for winter storage of pretreated leachate. Again, because the volume of leachate could increase over time, a bypass was provided to allow trucking of untreated leachate in the event of an emergency. The pretreated leachate receives further treatment and volume reduction through evapotranspiration in a series of four constructed wetlands. The first wetland is a subsurface wetland that uses sedges and bulrushes growing in a gravel bed to remove BOD. A vertical filter wetland to remove ammonia follows and uses common reeds growing in a fine gravel media. The next wetland is a free water surface wetland which uses bulrushes growing in topsoil. The topsoil removes heavy metals and other trace elements through adsorption. A second subsurface wetland polishes the leachate prior to discharge to the storage lagoon which serves as a wet well for the spray irrigation pumps. Deep-rooted prairie plants finish the treatment process by providing increased nitrogen removal and increased evapotranspiration.

Operational Experience

Since beginning operation in June 2000, the wetland treatment facility has been effective. BOD_5 concentrations in the treated leachate storage lagoon have averaged less than 5 mg/l despite significant variation in the raw leachate (17 mg/l to 9,000 mg/l). Total nitrogen concentrations in the treated leachate have averaged less than 10 mg/l during the growing season with raw leachate TKN averaging 200 mg/l. As expected, the most tolerant plant species are beginning to dominate the plant population in both the wetlands and the prairie. Sodium levels in the treated leachate have not adversely affected the prairie plants nor required gypsum application to the soil. Elevated chloride concentrations have occurred in the shallow groundwater aquifer under the prairie which discharges to a nearby creek. Although chloride breakthrough will occur at some point in the future, based on creek flow, no adverse effects are anticipated. MWA is considering construction of a second spray irrigation prairie in the future to allow alternate loading and resting of each application site.