

Electro-oxidation promising for landfill leachate ammonium removal

By Chumeng Wu



The onsite collection sump transfers leachate to the treatment system.

Landfill leachate treatment is a major engineering challenge due to the complex and concentrated contaminants within it. Depending on the age of the landfill, weather variations, and type and composition of the waste, leachate may contain large amounts of organic matter, ammonia-nitrogen, heavy metals, and chlorinated organic and inorganic salts.

Most commonly in North America, landfill leachate is either hauled or pumped to off-site municipal wastewater treatment plants for disposal. However, due to high ammonium concentrations, especially in the summer season, leachate disposed to off-site facilities has been a problem for plant owners. This is due to more stringent effluent discharge criteria, as well as interference with biological processes at the plants.

Onsite leachate treatment is an alternative to the increasing costs associated with

hauling and disposal of leachate to off-site wastewater treatment plants. Traditional leachate treatment technologies include biological treatment processes and physical/chemical processes.

Biological treatment processes include conventional activated sludge, sequencing batch reactors, membrane bioreactors, aerobic lagoons, trickling filters and constructed wetlands.

Physical/chemical processes include flotation, coagulation-flocculation and chemical oxidation. However, these treatment methods are not considered effective in handling the excessive amount of ammonium compounds present in leachate.

Electro-oxidation is fast becoming a promising process for removing ammonium from landfill leachate. Degradation of ammonium can be achieved by an indirect electro-oxidation process. With the presence of chloride ions in the leachate, hypochlorite ions can be produced by

electro-oxidation, which reacts with a wide variety of nitrogen compounds.

A pilot-scale leachate treatment system using electro-oxidation technology was designed, built, installed and tested by Xogen Technologies Inc. for onsite ammonium reduction. The purpose of the pilot project was to demonstrate an ammonia concentration reduction from over 400 mg/l to less than 200 mg/l; operational consistency, with stable performance 24/7 over a three month period; and a treatment cost of less than \$0.001 per litre.

Leachate treated in this pilot project was collected onsite from a sanitary landfill. It is required to treat its leachate because of the high concentration of ammonia in sewage sludge accepted for several years. Increases of ammonia concentration in the leachate of the landfill since 2007 have been observed. Although sewage sludge is no longer sent to the landfill, its leachate remains high

in ammonia. In 2010, the owner was directed to reduce ammonia levels to less than 200 mg/l from over 400 mg/l.

Leachate was pumped from the on-site collection sump at the landfill into the treatment system. The leachate was not pretreated, except for filtration with a 3 mm screen prior to the electro-reactor to avoid plugging by large debris. Leachate was then pumped through the electro-oxidation reactor and entered a liquid gas separator. This was designed to separate gas byproducts from the leachate. Treated leachate was then pumped from the pilot plant through an effluent pump.

The electro-oxidation reactor consisted of an array of anodes and cathodes spaced closely together. The design treatment capacity of the unit was 3.8 lpm. A programmable power supply was used to supply power to the electro-oxidation reactor.

The treatment system was controlled by a Schneider Electric programmable logic controller and was designed to run automatically without the presence of an operator. A human-machine-interface was designed and built by Versatech of Mississauga, Ontario, to operate, control and monitor the process.

Ammonium removal results

The pilot plant was operated continuously for three months. Ammonium concentrations in the treated leachate effluent varied from 69 mg/l to 196 mg/l, depending on the settings of power capacity and retention time.

Power supplied to the electro-oxidation reactor was found to be the dominant parameter that controls the ammonium removal rate. Concentrations in the leachate were found to be reduced significantly after increasing the power supplied to the reactor. The lowest ammonium concentrations were observed at the highest power capacity of 3.3 kW. Ammonium removal rate was increased by 24 percentage points from 30.8% at 1.9 kW to 54.3% at 3.3 kW.

Larger power capacity provides a stronger driving force for the reaction of ammonium reduction through electro-oxidation. Since the reaction consumes alkalinity, pH drop was also identified in the treated leachate. The pH level was reduced from 7.6 in raw leachate to 6.4 at 1.9 kW. It was further reduced to



The 3.8 lpm pilot-scale electro-oxidation leachate treatment system.

6.27 at 2.6 kW. By raising the power to 3.3 kW, pH was reduced to 6.1.

Additionally, the hydraulic retention time (HRT) is an important factor affecting ammonium removal from landfill leachate. HRT determines the time required for reactions to take place with ammonium ions in the leachate. At a HRT of 3.7 minutes, average ammonium concentration in the treated leachate was 235.8 mg/l. Average ammonium concentration was reduced by 28.2% to 169.2 mg/l by increasing the HRT from 3.7 minutes to 4.6 minutes. Ammonium concentration was further reduced by 46.2% to 90.9 mg/l when HRT was increased to 6.2 minutes.

Operation cost

There are two components to the operational cost of the pilot-scale electro-chemical oxidation system: electricity

to power up the electro-oxidation reactor, and a scaling control agent to remove deposits from electrode surfaces.

After process optimization, power consumption of the pilot leachate treatment system was maintained at around 2.9 kwh, while ammonium concentration was reduced to around 150 mg/l. Electricity cost of the pilot plant was \$0.0014 per litre of leachate treated. The chemical cost was \$0.00036 per litre of leachate treated. The operation cost of the pilot scale electro-oxidation system was found to be \$ 0.0017 per litre of leachate treated, which makes electro-oxidation a cost-effective alternative for onsite leachate treatment.

Chumeng Wu is with Xogen Technologies Inc. For more information, Email: ahughes@xogen.ca