Electro-oxidation promising for landfill leachate ammonium removal

By Chumeng Wu, P.Eng. M.A.Sc., Wastewater Process Engineer
Xogen Technologies Inc., 20 Robb Blvd, Orangeville, ON

Introduction

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

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

On-site leachate treatment is an alternative to the increasing costs associated with hauling and disposal of leachate to offsite wastewater treatment plants. Traditional leachate treatment technologies include biological treatment processes and physical/chemical processes. Biological treatment processes include conventional activated sludge (CAS), sequencing batch reactors (SBR), membrane bioreactors (MBR), aerobic lagoons, trickling filters and constructed wetlands. The physical/chemical processes include flotation, coagulation-flocculation, and chemical oxidation. However, these treatment methods are considered less cost-effective and are not effective to handle the excessive amount of ammonium compounds present in the leachate.

Electro-oxidation is fast becoming a promising process for removing the ammonium from landfill leachate. The 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 and react 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 from leachate. The purpose of the pilot project was to demonstrate the technology can reduce ammonia concentration from over 400 mg/l to less than 200 mg/l; operational consistency with stable performance 24/7 over a 3 month period; and achieve economic treatment cost.

Leachate treated in this pilot project was collected onsite from a sanitary landfill in New York State. The landfill is required to treat leachate from the landfill because of the high concentration of ammonia in sewage sludge generated by local treatment plants. The sludge was accepted at the landfill 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, the leachate remains high in ammonia. In 2010, the city was directed by the federal Environmental Protection Agency (EPA) to reduce the ammonia levels in its leachate to less than 200 mg/l from over 400 mg/l.

Xogen® Leachate Treatment System

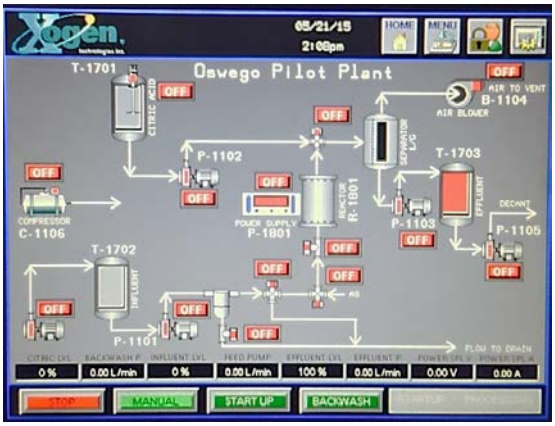
A pilot scale leachate treatment system using electro-oxidation technology was designed and built by Xogen Technologies Inc., for the purpose of ammonium removal from landfill leachate. Leachate was pumped from the onsite collection sump at the landfill into the treatment system.

The onsite leachate collection sump.

The leachate was not pretreated except filtered with a 3mm screen prior to the electro-reactor to avoid plugging by large debris. Leachate was then pumped through the electro-oxidation reactor and entered into a liquid gas separator. The liquid gas separator was designed to separate the gas-by-products from the leachate. Treated leachate effluent was then pumped off the pilot plant through an effluent pump. The electro-oxidation reactor consisted of an array of anodes and cathodes closely spaced together. The design treatment capacity of the pilot is 1.0 gpm. A programmable power supply was used to supply the power required by the electro-oxidation reactor.

The 1.0 gpm pilot-scale electro-oxidation leachate treatment system.

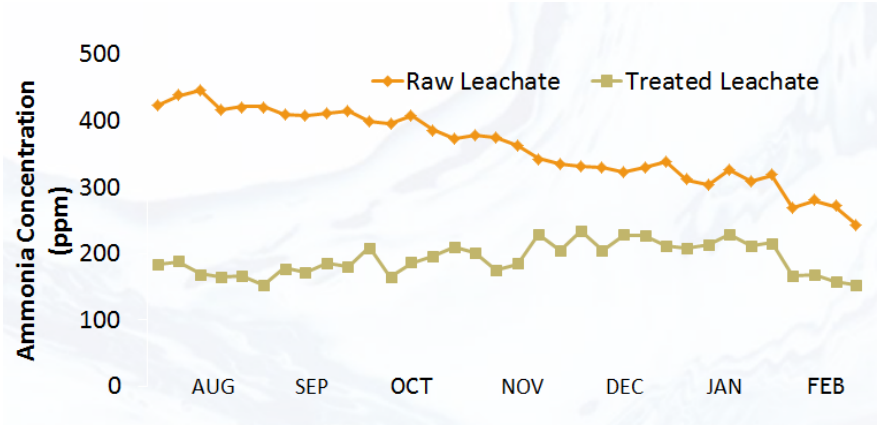
The treatment system was controlled by a Schneider Electric programmable logic controller (PLC) and was designed run automatically without the presence of an operator. A human-machine-interface (HMI) was designed and built by Versatech of Mississauga, Ontario to operate, control and monitor the process.



The Human Machine Interface (HMI) of the pilot-scale electro-oxidation leachate treatment system.

Ammonium Removal Results

The pilot plant was operated 24/7 continuously for three months, ammonium concentrations in the treated leachate effluent remained below the treatment limits at 200 mg/l, varied from 69 mg/l to 196 mg/l, depending on the settings of power capacity and retention time.

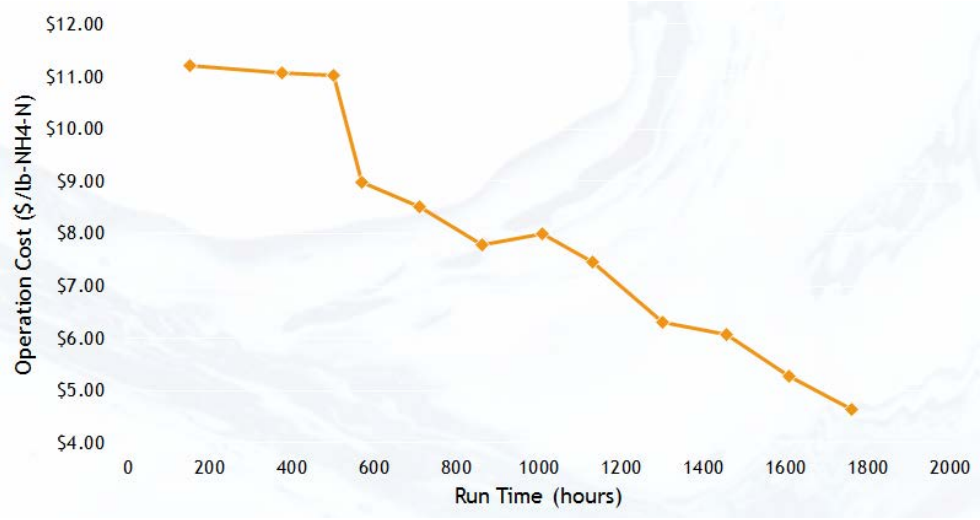


Ammonium removal results from landfill leachate.

The power supplied to the electro-oxidation reactor was found to be a dominating parameter that controls ammonium removal rate from the leachate. The ammonium concentrations in the leachate were found to be reduced significantly after increasing the power supplied to the electro-oxidation reactor. The lowest ammonium concentrations were observed at the highest power capacity of 3.3kW.

Operation Cost

There are two components to the operational cost (OPEX) of the pilot scale electro-chemical oxidation system: cost of electricity to power up the electro-oxidation reactor and cost of scaling control agent to remove the scaling deposits from the electrode surfaces. The OPEX of the pilot is shown in the figure below.



Operation cost of the pilot scale leachate treatment system.

Summary

A pilot scale electro-oxidation system developed by Xogen Technologies Inc. successfully achieved ammonium removal from landfill leachate. The ammonium concentration in the leachate was successfully reduced from 414 ppm to the treatment target of 200 ppm after the treatment.

The conclusion was that for most applications involving reduction of ammonia between 200 ppm to 700 ppm, the total capital and operation cost will be between 1.5 to 5 cents per gallon.