Leachate treatment by direct capillary nanofiltration

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Introduction

Essent is a multi-utility company with, as its core activities, energy production and distribution, cable communications and waste management. Essent is operating 8 landfills, including the Wijster Landfill with an extended leachate treatment and LFG-utilization. The present leachate treatment consists of (see figure 1) a biological pre-treatment (activated sludge system/ nitrification-denitrification), reverse-osmosis (tubular membranes and spiral-wound membranes) and an evaporation plant (multi-stage flash) treating the RO-concentrate. The residue of the evaporation plant is discharged to former salt-mines after solidification.
Desalination by reverse osmosis has been installed in 1986 caused by the stringent effluent criteria (chloride 200 ppm, total nitrogen 10 ppm) for the receiving surface water. The present treatment system (250,000 m^3/a) needs an upgrading, while:

- The system is expensive (all-in €18/ m^3 leachate)
- The tubular RO-system is technically spoken no more "state of the art"
- The high amount of residue (10,000 tons/a) makes the system not sustainable.

Since 1999 Essent and Norit Membrane Technology studied on pilot plant scale the possibilities of tubular nanofiltration and capillary nanofiltration.
The objectives of nanofiltration are:

- Reducing the amount of residue by separating the monovalent salts (chloride, potassium and sodium) from the other components in the leachate
- Concentrating the organic compounds with heavy metals and organic micro pollutants.

The concentrate of the nanofiltration (CF is 10 or higher) will be incinerated on the Essent location; another possibility is recirculation on the landfill, most of the components will be adsorbed. The permeate of the nanofiltration (with monovalent salts) will be discharged to the sea.

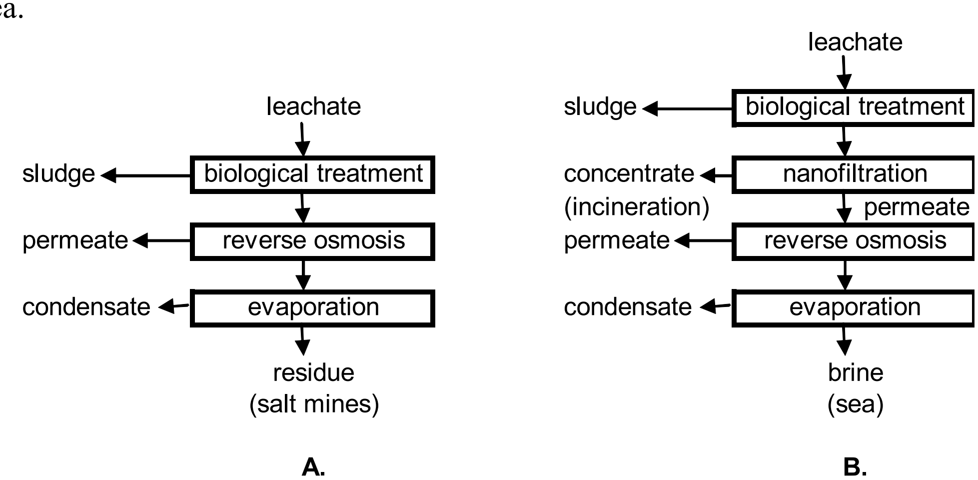

Figure 1. Existing leachate treatment system (A) and proposed future system (B).

Nanofiltration pilot scale research on biological pretreated leachate.

In 1999 the research started with tubular nanofiltration modules (diameter 15 mm). With a trans membrane pressure of 20 bar, a circulation velocity of 3 m/sec and a concentration of 10 times fluxes were obtained of approx. 25 l/m^2 hr with a good quality permeate.
That time the capillary nanofiltration was introduced (on the basis of capillary ultrafiltration membranes with a polyamide layer and a diameter 1.5 mm) with several advantages (see also www.membranetechnology.com):

- Less energy consumption due to TMP of 6 bar and a lower circulation velocity (2 m/sec); reducing the energy consumption from 6 to 3 kWh/m^3 permeate.
- Less chemical consumption for cleaning because of the lower volume to surface ratio of the capillary membranes.

During all the test-runs in 2002 the biological pretreated leachate has been mechanically screened (200 µm), pH adjusted (range 7 to 7.2) and supplied with anti-scalant. With a re-circulation velocity of 2 m/sec and a concentration of 10 times the average flux was 22 to 24 l/m^2 hr.
The nanofiltration removed from the biological pretreated leachate: COD and NKj for 93%, sulfate 70%, Cd and Hg 90%, PAH and EOX over 75%.
The color changed from dark brown to transparent light-yellow.

Proposed full scale plant direct nanofiltration.

By a preliminary design of the full scale plant (capacity 30 m^3/hr permeate) the overall investment costs and the operating costs have been calculated. The mechanical/electrical equipment (8 stacks, 10 modules per stack, module of 20 m2) including cleaning in place equipment and fully automatic process control needs an investment from approx. 900,000 €, including the membrane costs of 300,000 €. The operating costs (maintenance, electricity, chemicals, operator) including depreciation and interest (6 %) of the equipment (10 years) and membranes (3 years) are 1.70 € per m^3 permeate.

Prospective of nanofiltration in leachate treatment

The selection of l*eachate treatment systems* depend on the standards to meet for the receiving surface water. In general, the self-purification capacity is insufficient for concentrated discharges and therefore treatment in a WWTP or biological leachate treatment plant has to reduce oxygen consumption of the leachate (BOD removal and nitrification).
In case of discharge of to more critical receiving water (e.g. oligotrophic lakes) denitrification and phosphorous removal is a must.
The next step is removal of color, heavy metals and organic micro pollutants (PAH, EOX etc.) by oxidation (ozone), activated carbon systems or *NANOFILTRATION*.
If the receiving water cannot dilute the salt content in a proper way and is used for agricultural purposes (cattle water, irrigation) or is a source for potable water, desalination of the leachate is necessary by reverse osmosis, electro-dialysis or evaporation.