ACTA ENVIRONMENTALICA UNIVERSITATIS COMENIANAE (BRATISLAVA)
Vol. 19, Supplement (2011): 174–178 ISSN 1335-0285

NEW TRENDS IN LANDFILL LEACHATE TREATMENT

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Abstract: *This paper deals with the application of membrane separation processes for landfill leachate treatment. New methods that have wider usage and yield better results than conventional techniques are now being employed for remediation of contaminated sites. An important aspect to consider in the selection of a new technology is its economy. Among the new technical alternatives available are membrane separation processes. Membrane separation processes found wide use in recent years in many industries and their proliferation into areas dominated by other technologies is expected. These effective separation processes are already utilized in many areas of human endeavor including the removal of landfill leachates. The main focus of this paper is presentation of this worldwide used environmental-friendly technology and demonstration of efficiency on a real samples of czech landfill leachate.*

Keywords: membrane separation, reverse osmosis, landfill leachate treatment, environmental-friendly technology

INTRODUCTION

Membrane processes are used to separate homogeneous or heterogeneous liquid solutions and mixtures, gaseous mixtures, and suspensions of solid particles of microscopic dimensions (less then ca. 1.10^{-5} m) in liquids. Membrane processes generally have high separation efficiency. The separation selectivity depends on the particular membrane process. Because membrane separations take place at ambient temperatures, there is no damage to thermo-labile substances. The membrane units may be operated remotely with the help of modern control systems that reduce the cost of labor. Membrane processes are relatively easy to scale up. The technique may be applied in low-volume batch equipment or in a continuous large capacity plant.

Membrane processes are based on the separation of the solution into two distinct streams with the help of a membrane. A driving force pushes some of the solution components through the membrane in a stream that is referred to as the permeate. Components that do not pass through the membrane form the other stream – the concentrate. The difference across the membrane in pressure, concentration, electrical potential, or temperature serves as the driving force.

METHODICS

Landfill leachate forms when rainwater and groundwater infiltrate the body of the landfill. The volume of the leachate depends to a large degree on the climate. The leachate composition depends on the type of the waste and the chemical reactions taking place in the landfill. The construction of the landfill, its age and the degree of compaction of the waste also affect the quality of the leachate. Landfill leachate usually contains large quantities of dissolved solids. A conventional wastewater treatment plant is designed to remove only substances of organic character, heavy metals and various forms of nitrogen. It cannot handle dissolved inorganic salts; in certain cases it even produces an increase in their concentrations (Cath et al. 2006).

Reverse Osmosis was used for the purification of landfill leachates. In this process the treated solution is separated with the help of a semipermeable membrane into two streams – a permeate and a concentrate. The permeate is composed of practically pure solvent, while the concentrate contains all the chemicals that did not pass through the membrane. At higher pressures than the osmotic pressure of the treated solution, the osmotic flow of the solvent is reversed. Reverse osmosis operates at high pressure gradients. The higher is the concentration of salts in the feed liquid, the higher is the osmotic pressure and a higher operating pressure must be applied to overcome it. One of the many advantages of the process is the fact that the separation takes place on the ionic level.

In the USA, Western Europe and Japan, membrane technology is already widely used in landfills. To some degree, the method is also being applied in landfill remediation in the Czech Republic. A reverse osmosis unit was installed in Wijster in Netherland and another unit in Ratorf in Plön in Germany. Both units have two stages. The raw landfill leachate is first pretreated by filtration and its pH is adjusted. The separation efficiency, calculated in terms of ammonia nitrogen and COD, exceeds 98 % (Linde et al. 1995). The well-functioning reverse osmosis plant in a communal landfill in Ihlenberg in Germany showcases the advantages of up-to-date-membrane processes. The plant treats 36 m^3 per hour of the leachate. In the course of ten years of operation the membranes had to be replaced just once. The two stage system operates with the separation efficiency of organic and inorganic components around 99 %. The operating pressure depends on the amount of salts in the leachate and ranges from 3.6 to 6 MPa (Peters 1998). The reverse osmosis unit installed in the city of Yachiyo in Japan (“Clean center KINU”) treats landfill leachate consisting mainly of ashes and nonflammable, inert, and biologically non-degradable materials. The unit has been in operation since April 1999 and has a capacity of 70 m^3 per day (Wiszniowski et al. 2006).

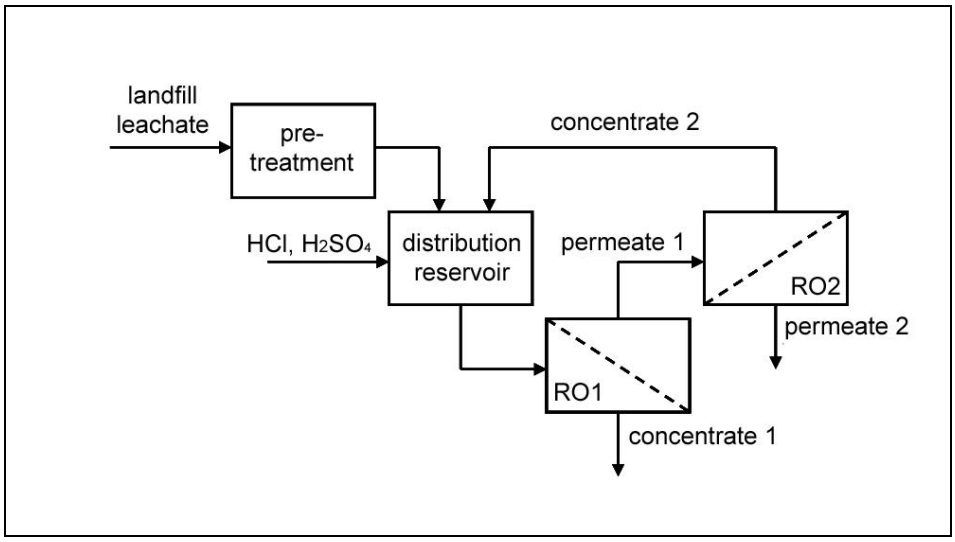

Fig. 1: Typical schema for landfill leachates purification

Figure 1 describes typical purification schema for landfill leachates. This schema contains usually form of pre-treatment like coarse filtration or coagullation, pH adjustement for better removal of some pollutants and 2 stage reverse osmosis. Concentrate from 1st stage is usually removed in solidification or in evaporator. Permeate from 2nd stage is released into the environment.

EXPERIMENTAL

We have the possibility to see many types of landfill leachates in laboratory. They are from municipal waste landfills and hazardous waste landfills too. On the basis of qualitative and quantitative analysis we can say landfill leachates composition differs. That is why we choose individual approach to every landfill leachate.

Let's take two samples of Czech landfill leachates and let's verify that abroad operating technology can operate here in Czech Republic.

First landfill leachate comes from hazardous waste landfill situated in Moravia. It's a colourless liquid with alkaline pH (9.8) with ammonia odour containing approx. 30 g/l dissolved matter. Based on performed group of experiments two stage separation experiment with pH adjustement showed best separation of all pollutants. Working conditions: 1st stage – coarse filtration, pH adjustement with HCl to value approx. 6.5, working pressure 5 MPa, conversion into permeate 75 %; 2nd stage – no pretreatment, working pressure 4 MPa, conversion into permeate 90 %. Ammonia nitrogen removal was 98 %, all other pollutants removal was higher than 99 %. Conductivity of feed was decreased to surface water conductivity value.

Second landfill leachate comes from municipal waste landfill situated in Bohemia. It's a mild odoured brownish liquid with pH = 8 containing approx. 12 g/l dissolved matter. Based on performed group of experiments two stage separation experiment with no pretreatment showed best separation of all pollutants. Working conditions: 1st stage – coarse filtration, working pressure 4 MPa, conversion into permeate 80 %; 2nd stage – no pretreatment, working pressure 2 MPa, conversion into permeate 95 %. Ammonia nitrogen removal was 99.4 %, all other pollutants removal was higher than 99 %. Conductivity of feed was decreased deep under surface water conductivity value.

Tab. 1: Composition of landfill leachates and final 2nd stage permeates

pollutant	unit	hazardous waste		municipal waste	
		leachate	permeate	leachate	permeate
Mg	mg/l	4.8	< 0.2	147	0.3
Ca	mg/l	2773	12	98	< 0.5
Na	mg/l	5959	23	1760	< 1
K	mg/l	2687	13	767	0.7
Cl^-	mg/l	14623	93	2087	< 7
N(amon.)	mg/l	210	4	560	3.1
NO_3^-	mg/l	46	1.4	127	< 1
SO_4^{2-}	mg/l	728	< 10	24	< 1
pH	–	9.8	7.0	8.0	6.7
conductivity	mS/cm	37.2	0.4	12.15	0.05
TIC	mg/l	59	6	1173	3.1
TOC	mg/l	29	2	353	< 1

All experiments were carried out in laboratory scale under operating temperature 20 °C. Laboratory experiments to measure the separation efficiency of the membrane treatment must be performed before any field application. Membrane separation unit LAB M20 was used. The equipment was customized for batch processing. The actual separation takes place on a plate-and-frame reverse osmosis module DSS equipped with membranes for reverse osmosis signed RO98pHt (manufacturer ALFA LAVAL, Sweden). The module has a total membrane area of 0.6 m^2. The membranes function through a wide range of pH (2 – 11). A Rannie piston pump with maximum operating pressure of 6 MPa was used. A separate water supply was used to maintain the pistons of the pump moist. A flow liquid-liquid heat exchanger cooled the membrane module. Water from the faucet served as the cooling agent.

CONCLUSION

Membrane separation is modern and effective technology for almost all types waste water treatment including landfill leachates. Effectivity and availability of this technology was demonstrated on many real applications in

landfills abroad. Membrane separation expects currently their expansion in Czech Republic, but based on results membrane separation is suitable for Czech landfill leachates treatment too.

ACKNOWELEDGEMENT

This work was supported by the research grant MSM6046137308.

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