Comparison of pressure-driven membrane processes and traditional processes for drinking water production in Europe based on specific impact criteria

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Abstract

Due to the policy of many governments of encouraging the use of alternative water sources instead of groundwater, there is a clear need for enhanced water purification systems such as pressure-driven membrane processes. In this article a comparison is made between drinking water production from surface water using pressure-driven membrane processes and using traditional surface water treatment systems. Three alternatives are considered: Traditional treatment using coagulation/flocculation, sand filtration, physicochemical softening, activated carbon adsorption and disinfection (Process A); spiral-wound nanofiltration with ultrafiltration pretreatment followed by marble filtration and disinfection (Process B); and direct capillary nanofiltration with only a limited pretreatment and post-treatment by marble filtration and disinfection (Process C). An evaluation protocol was used (CRIME-DAV), in which the following impact criteria were taken into account: Quality and public health, operational aspects, the environment; the landscape, the economy, and administrative, legal and societal acceptance. The comparison of these aspects shows that none of the considered alternatives is favourable for all aspects. In practice, weight factors used in the protocol may have to be revised, shifting the optimal solution to one of the three processes. The general comparison is to be considered a rough indication and a template for a more detailed practical study. Process A proved to be advantageous for the aspects 'environment' and 'economy' but performance for 'quality and public health' and 'landscape' was poorer than for alternatives B and C. The latter both had a particularly good performance for 'quality and public health' and "operational aspects". Process C was more advantageous than B for economical aspects and the environment.

Keywords: pressure-driven membrane processes; drinking water; microfiltration; ultrafiltration; nanofiltration; reverse osmosis; environmental impact

Introduction

The breakthrough of pressure-driven membrane processes is essentially related to the shift from groundwater to surface water as an alternative water source for drinking water supply, which is a priority for many European governments, including the Flemish government (Mina Plan 2, 2002). The decrease of the groundwater level and the risk of droughts in natural areas by the extraction of groundwater by drinking water companies, agriculture and industry, and by the decrease of the infiltration volume by urbanization are the main reasons for this policy (Van Dijk, 1992). Quota and taxes on the use of groundwater are two methods for influencing the use of water sources (Van Damme et al., 2001).

Whereas groundwater requires only a limited treatment before it is fit for distribution, surface water and other water sources need an enhanced treatment because of the occurrence, or the risk of occurrence, of a wide range of contaminants. An overview of possible contaminants in surface water and in groundwater is given in Table 1 (Degrémont, 1991). Traditional surface water treatment focuses on the removal of contaminants present in groundwater; other contaminants are hardly removed, so that the treatment scheme has to be extended with processes such as adsorption on activated carbon and thorough disinfection.

During the last decade, pressure-driven membrane processes made a major breakthrough in drinking water production (Jacangelo et al., 1997). New plants such as Méry-sur-Oise, France (Gaid et al., 1998; Ventresque et al., 1997) and Heemskerk, the Netherlands (Kamp et al., 2000) often make a clear choice for membrane processes for drinking water production, mainly because of the superior technical performance and because a combined removal of various pollutants can be obtained. The first years of operation already prove that the membrane process is reliable (Ventresque et al., 2000). Other plants such as the integrated membrane treatment process consisting of microfiltration followed by nanofiltration in Barrow, Alaska, which treats surface water with high concentrations of natural organic material including disinfection by-product precursors, and significant concentrations of *Giardia* and *Cryptosporidium* (Lozier et al., 1997) provide a realistic view of possible water production methods in the (near) future. Ranging from microfiltration to reverse osmosis, pressure-driven membrane processes are able to remove nearly all undesired compounds from a given water source (Mulder, 1996; Van der Bruggen et al., 2003). Especially where a wide range of possible contaminants has to be removed, membranes are a safe barrier against contamination of the product water. A fine example is the water treatment plant of Koksijde, Belgium (Van Houtte et al., 1998) where municipal

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