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Demonstration of a new hybrid process for the decentralised drinking and service water production from surface water in Thailand

M. Sartor[a], B. Schlichter[a,c]*, H. Gatjal[a], V. Mavrov[b]

[a]*Gesellschaft für umweltkompatible Prozeßtechnik mbH i.L., Im Stadtwald Geb. D3 3, D-66123 Saarbrücken, Germany*
email: bernhard.schlichter@hydac.com
[b]*Department of Process Technology, Saarland University, Campus Dudweiler, Zeile 4, D-66129 Dudweiler, Germany*
[c]*HYDAC Process Technology GmbH, Am Wrangelflöz 1, D-66538 Neunkirchen, Germany*

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Abstract

A hybrid process, consisting of ozonation and membrane filtration, followed by activated carbon filtration, was studied in demonstration scale for the drinking and service water production from surface water in Thailand. The main focus of this study centred on the evaluation of the entire process, especially on the membrane reactor technology under tropical conditions. To this end a demonstration plant with a capacity of about 5 m^3/h in continuous operation was designed and build up in a 40 ft sea container. Submerged ceramic micro- (MF) and ultrafiltration (UF) membranes with a cut-offs of 200 and 80 nm were used for the separation process inside the ozone reactor. Pilot tests with different kinds of surface water were carried out in Thailand, as a typical tropical country. The tests have shown that during ozonation the permeate fluxes of the submerged membranes have constant fluxes on a high level for UF in a range of 60 to 80% and for MF in a range of 35% of the pure water flux. The low amount of concentrate generated by this process contains a high amount of mineralised elements and is harmless for discharging.

The comparison of the different raw water qualities with the qualities of the produced freshwater have shown, that the process is suitable for the decentralised production of drinking and service water in tropical countries. Finally a first evaluation of the economic efficiency of this process concept is given as an outlook.

Keywords: Ozonation; Drinking water; Service water; Surface water; Membrane reactor

*Corresponding author.

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1. Introduction

In many densely populated areas of Thailand, there are quite dangerous levels of surface subsidence due to excessive ground water withdrawal. Since there is a lack of alternatives for the supply of process, service and drinking water, most of the freshwater needed is withdrawn illegally from ground water wells [1]. For this reason, the country's environmental policy is putting pressure on industry so that investments are made in alternative water technologies. In contrast to many European countries, in which a nationwide pipeline network ensures water supply, there is a growing need, not only in Thailand but all over Asia, for small decentralised and compact drinking water installations, which are characterised by versatile operation, good water quality, high operational reliability and low operating costs [2].

Since the quality of surface water can vary to a great degree, particularly in tropical countries where it is subject to major seasonal fluctuations, individual or suitably adapted water treatment technologies are frequently needed for decentralised, reliable drinking and service water production [3]. The natural chemical reaction processes and the quality of surface water bodies in countries with tropical climates result in more intensive biological processes and thus comparably quicker and more pronounced humification processes. Ultimately this means that organic contamination in water bodies is considerably higher than in more moderate climatic zones. There is an increased growth in algae and microorganisms. Concentrations of organic impurities in water, measured as TOC (total organic carbon) are between 15 and 50 mg/L depending on place and season, making them twice as high on average as those found in European surface water bodies. These conditions have to be taken into account when planning, constructing and operating water treatment plants. The new process under study for surface water treatment, consisting of ozonation and membrane filtration is a very promising alternative to conventional technologies, particularly for decentralised small-scale plants with capacities of up to several cubic metres per hour. Fundamental investigations into this process combination have already been performed in the past and form the basis of the pilot plant constructed in this project [4–6].

This study mainly focuses on the testing of this technology in pilot scale under tropical conditions. To this end, a test plant for drinking and service water production with a capacity of up to 5 m^3/h was set up in a 40-feet, air-conditioned container and tested for several months in the Thai province of Chonburi. Basically, the plant consists of a reactor tank for water ozonation and membrane filtration fitted with ceramic, multichannel flat sheet membranes with a cut-off of 200 nm (microfiltration) and 80 nm (ultrafiltration) as well as downstream activated carbon filtration followed by a disinfection stage.

2. Experimental

The applied water treatment process is a multi-stage process, essentially consisting of an oxidation stage using ozone to oxidise the pollutants and to control membrane fouling, a physical separation stage based on submerged ceramic ultrafiltration membranes to remove particles and micro-organisms from the water and an activated carbon stage to reduce the amounts of organics. In this new process, ozonation is used not only for oxidation processes and disinfection as in conventional water treatment systems but for membrane fouling control, since it is possible to destroy most of the pollutants which are formed through oxidation [7,8]. This also means that retentate with high pollutant concentrations is not generated in the membrane process but rather only small quantities of mineral sludge. The simplified flow chart in Fig. 1 illustrates this new water treatment process.