

**Title:** Membranes for Water Treatment  
**Speaker:** Ranil Wickramasinghe, Associate Professor  
Department of Chemical and Biological Engineering  
Colorado State University, Fort Collins, Colorado, USA  
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**Abstract:**

Membranes find numerous applications for water treatment. In this presentation three membrane based unit operations will be discussed: gas membranes for cyanide removal, microfiltration for arsenic removal and nanofiltration/reverse osmosis for treatment of oily waters.

A micro-porous hydrophobic membrane may be used to separate two aqueous streams resulting in an immobilized gas-liquid interface at both membrane surfaces. These gas membranes may be used to conduct non-dispersive absorption and stripping at both gas liquid interfaces. While numerous laboratory scale studies have considered the use of gas membranes for removal of cyanide from wastewaters, data from a pilot scale facility indicate that the presence of other volatile species can compromise the rate of cyanide removal. Further water vapour transport by osmotic distillation can occur. These results highlight the importance of considering real feed streams when developing a gas membrane process.

Arsenic contamination of drinking water is a concern in many parts of the world. In the United States, the Environmental Protection Agency recently reduced the maximum contaminant level of arsenic in drinking water from 50 to 10 ppb. In Bangladesh the arsenic concentration in drinking water can be as high as hundreds of parts per billion. Here arsenic removal by coagulation and microfiltration has been investigated using groundwater from a city in southern Colorado and from Sonargaon in Bangladesh. The use of ferric ions followed by microfiltration is effective in reducing the arsenic concentration in the feed water. However the actual efficiency of arsenic removal depends on the raw water quality. Further, addition of a polyelectrolyte coagulant aid may lead to improved permeate fluxes during tangential flow microfiltration but has little effect on the residual arsenic concentration.

Water that is co-produced during oil and gas manufacturing represents the largest source of oily wastewaters. Treatment of this produced water could improve the economic viability of the oil and gas field and lead to a new source of water for beneficial use. Two nanofiltration and one low pressure reverse osmosis membrane have been tested using three produced waters from Colorado. The membranes were analyzed before and after produced water filtration using field emission scanning electron microscopy (FESEM), attenuated total reflection Fourier transform infrared (ATR-FTIR) spectroscopy and X-ray photoelectron spectroscopy (XPS). XPS data indicate adsorption of organic and inorganic species during filtration. FESEM and ATR-FTIR data support these findings. Our results indicate the value of using multiple surface characterization methods with different depths of penetration in order to determine membrane fouling. Depending on the quality of the produced water and the water quality requirements for the beneficial use being considered, nanofiltration may be a viable process for produced water treatment.

## **Biography of A/Professor Wickramasinghe**

Dr. Wickramasinghe obtained his BEng (Chem) and MEng at Melbourne University and PhD at the University of Minnesota. He worked in the biotechnology and biomedical industries, including Sepracor, for 5 years before joining the department of chemical and biological engineering at Colorado State University. His industrial experience includes designing improved hollow fiber microfiltration modules, designing micro filtration based systems for blood processing, as well as developing virus clearance methods for the downstream processing of biopharmaceutical products.

Dr. Wickramasinghe's current research interests are in separation processes and virus clearance with specific application to biotechnology and biomedical engineering. He obtained a prestigious CAREER award from the National Science Foundation in 2000 and was Montfort Professor from 2004-2006. He is currently also assistant director of the new School of biomedical engineering at CSU. Current research topics include virus clearance during bioreactor harvesting and improving microfiltration. In the area of biomedical engineering, active research projects include improving the design of blood oxygenators, centrifuges and other biomedical devices. Funding for Dr Wickramasinghe's research comes from the National Science Foundation, Colorado Institute for Research in Biotechnology and from industry.