Indo-Bulgarian Project

Advanced technologies for industrial wastewater treatment leading to zero-discharge concept

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Abstract:

Nowadays, environmental management is considered as a very important subject in industrial domain, mostly because of higher awareness among the people for environmental conservation and sustainable development, and stricter discharge norms by various regulatory bodies. For economic sustainability, an integrated approach towards waste treatment is now being favored and efforts are underway to develop a fully integrated effluent treatment process conforming to "zero effluent concept". There is no readymade solution that is applicable for any industry, rather it is highly case-specific and process is mostly tailor-made for application to a particular type of industry.

Researchers all over the world feel that Membrane Process could play a pivotal role in integrated effluent treatment process leading towards implementation of so called zero-discharge concepts. The particular advantage of membrane separation processes is that it operates without heating, and thus is energetically usually efficient than conventional thermal separation processes (distillation, sublimation or crystallization). The cold separation by membrane processes has been established particularly in the food technology, biotechnology and pharmaceutical industries. Depending on the type of membrane, the selective separation of certain individual substance or substances in mixtures is possible. Important technical applications include drinking water by reverse osmosis (worldwide approximately 7 million cubic meters annually), filtrations in the food industry, the recovery of organic vapors such as gasoline vapor, recovery and the membrane-electrolysis for chlorine production. But also in wastewater treatment, the membrane technology is becoming increasingly important. With the help of UF and MF (Ultra-/Microfiltration), it is possible to remove particles, colloids and macromolecules, so that wastewater can be disinfected in this way, and simultaneously the valuable component can be recovered and recycled/reused.

Membrane processes find widespread applications in dairy industries, which include:

- The production of milk protein concentrates and isolates (containing up to 90% protein on a dry basis) by ultrafiltration,
- Microfiltration of dairy liquids to reduce microbial loads ("cold sterilization"), for selective fractionation of dairy components and for enhancing functional properties of dairy ingredients,
- Production of cheese using ultrafiltered milk; both soft (e.g., cottage) cheese and hard (e.g., cheddar) cheese production from UF-milk retentate have been studied, primarily with a view to understanding the factors that govern the textural, ultra-structural and organoleptic properties of the UF-cheese, and process modifications to optimize these properties,

- Concentration of milk by reverse osmosis, to save energy in the manufacture of concentrated and dried milk products, and to reduce bulk transportation and refrigeration costs.

A good example of the successful application of membrane technology, and ultrafiltration in particular, is the processing of cheese/casein whey. Whey is a by-product of the dairy industry. It is the liquid fraction that is drained from the curd during the manufacture of cheese/casein. Typically every 100 kg of milk will give about 10-20 kg of cheese/casein depending on the variety, and about 80-90 kg of liquid whey. Its disposal is a major problem for the dairy industry, partly due to its composition. It has a low solids content and a very unfavorable lactose:protein ratio which makes it difficult to utilize as-is. The biological oxygen demand (BOD) is 32,000 to 60,000 ppm, which creates a very severe disposal problem.

Despite continuing efforts to find uses for the whey, either as-is or in dry form, or its major components (high quality protein and lactose), it is estimated that as much as 40-50% of the whey produced is disposed-off as sewage, with the rest being used primarily for animal feed or human food. World production is estimated at 80 to 130 million tons per year with USA producing about 30 million tons per year. Since cheese/casein consumption is increasing around the world, it can be concluded that the whey disposal problem is getting worse. This explains why membrane technology has attracted the attention of cheese and whey producers: the appropriate membrane can simultaneously fractionate, purify and concentrate whey components, thus enhancing their utilization and reducing the pollution problem.

In dairy industries, planned use of MF/UF membranes could lead to practically complete separation of fat and whey protein. Lactose could be recovered as such, or it could be converted to galacto-oligosaccharides (GOS), a high-value neutracuticals, by using enzymatic membrane reactor (EMR). In pulp & paper industries, after the recovery of lignosulphonates (LSs) by a train of UF membranes, one could recover the carbohydrates or convert them to some high-value product, again using the concept of EMR.

Another important and prospective application of MBR and EMR is the treatment of oily wastewater. Suitable EMR configuration could lead to the effective use of oily wastewater for the production of bioethanol, which could be blended with gasoline to add fuel value, at the same time, reducing the severe pollution problem from the discharge of oily wastewater to natural resources. In this respect, enzymatic and microbial routes have been investigated and enzyme immobilized membrane bioreactor seems to be prospective to give maximum yield of ethanol. More optimization of the process is required before complete commercial implementation of EMR in the treatment of oily wastewater.

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