CASE STUDY

Treating Whey and Dairy Applications for VSEP

Dairy products are enjoyed all over the world and are a diet staple for many people. With the growing demand for dairy products such as Greek yogurt, the handling of the increase in waste byproducts is a growing concern. Whey is a byproduct that cannot be discharged to surface water or land applied due to the COD and BOD that are an environmental hazard to agriculture and aquatic wildlife. Normal dairy production plant wastewater is in the range of 2000 to 3000mg/L BOD which is 10 times the strength of domestic sewage [1]. The amount of whey produced from the original product can be 90% [2] for cheese and up to 75% for Greek yogurt. The current uses for whey are limited and alternative treatments are necessary.

VSEP is able to treat the whey on-site to separate and concentrate the solids to the industry requirement for a usable product while producing clean water that can be reused in the process or discharged. New Logic Research has provided VSEP equipment for whey filtration since 1997 and continues to provide separation solutions for a wide variety of applications within the dairy industry.

Background

Whey is the liquid portion of milk and consists of lactose, protein, ionic content and fat[3]. The milk is coagulated with enzymes or an acid to curdle the milk to separate the whey and milk solids. Whey can be further identified as sweet whey for processes that use an enzyme such as cheese making and acid whey for process that use an acidic source for curdling such as yogurt and cottage cheese making. The source of milk can vary based on product and geographic location. Common sources include cows, goats, sheep, and buffalo. Some less common sources from mammals include horse, donkey, yak, and moose.

Yogurt is produced by adding bacteria cultures to milk and allowing the mixture to ferment. During the fermentation process lactic acid is produced and gives yogurt its texture and flavor.

The milk used is not limited to the examples mentioned and can be from non-dairy sources such as soy, coconut, and almond milk. Yogurt based products are also made into soups, beverages, and frozen desserts.

Greek and 'Greek style' yogurt have recently increased in popularity. Greek yogurt has a thicker texture and almost double the protein and reduced lactose and carbohydrates compared to regular yogurt, which makes it appealing for the health conscious. Greek yogurt is strained or mechanically separated to remove the whey from the milk solids. At a commercial scale, one part of final product produces two to three parts of acid whey.

Treatment Options

Whey can be used for the base of many products such as ricotta cheese. It is a source of protein and lactose and is commonly used as animal feed, food additives, and nutritional supplements. Sweet whey can be used for infant formula, but acid whey disposal is more difficult. The increasing volume of whey produced is greater than the demand, so disposal has become an urgent issue.

In some cases, the whey can be land- applied. This may not be an option for facilities with limited space or those lacking proper permits, thus many must have their whey hauled offsite. For commercial production plants, the amount of whey hauled on a daily basis is not economically practical.

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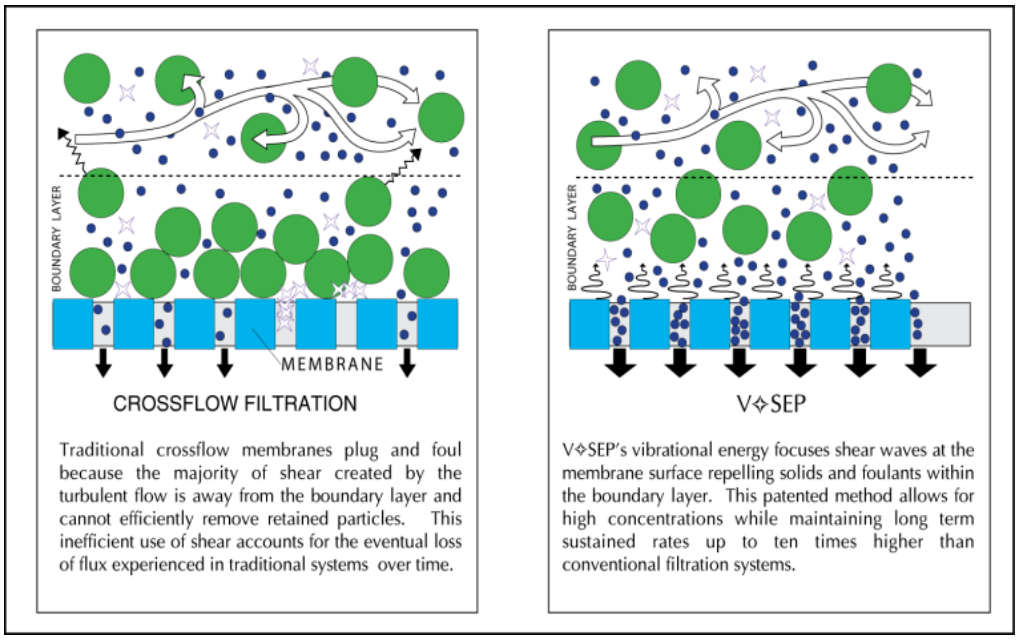
Whey can also be treated biologically with an anaerobic digester and produce biogas. The footprint of biological treatment systems can be very large and not suitable for plants with limited space or lower production rates. Digester effluent requires further treatment to meet surface water or sewer discharge requirements, and the system can have a large chemical consumption cost.

Membranes are a semi-permeable boundary layer; with pressure, membranes will allow permeate to pass through the membrane while rejecting solids based on the size classification of the membrane. Membranes allow for specific particle separation such as water and protein. The whey can be treated in a variety of ways depending on the separation goal. The performance and quality is reliable, and CIP cleanings can recover performance over time.

VSEP Solution

VSEP has employed the most effective technique for membrane separation. For many years membrane companies have relied on the “crossflow” of the fluid and the resulting dynamics to enhance performance and to keep layers of foulants and cakes from blinding off the membrane surface. This technique has limited success, however, and there are many drawbacks. Crossflow systems are still prone to fouling. Because of the needed crossflow, the percentage of the feed recovered as permeate versus the concentrate is very low.



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New Logic Research uses vibratory shear induced by cyclical torsional rotation. The surface of the membrane is moving inversely at a rate of 55 hertz. This action greatly reduces fouling and eliminates the formation of blinding cakes on the membrane surface. As a result, VSEP is capable of concentration unattainable in other membrane systems.

VP filter packs are constructed from flat sheet membranes ,and can fractionate, purify, and concentrate whey and it's individual components by using different membranes in series. The versatility of the system allows for uses in a wide range of applications in the refining industry, pulp and paper, agriculture, and wastewater to name a few.

There are four main categories of membrane filtration. These are determined by the pore size or molecular weight cutoff:

Filtration Type	Particle Size Cutoff	Molecular Weight
Reverse Osmosis	≤ 0.001 µm	≤ 100 Daltons
Nanofiltration	0.001 - 0.01 µm	100 - 1000 Daltons
Ultrafiltration	0.01 - 0.1 µm	1000 - 500,000 Dalton
Microfiltration	≥ 0.1 µm	≥ 500,000 Daltons

Reverse Osmosis Membranes

The first category of membranes is Reverse Osmosis (RO). These are the tightest membranes for separating materials. They are generally rated on the % of sodium chloride they can remove from a feed stream. They may also be specified by molecular weight cutoff. The rejection of NaCl should be greater than 95% for a membrane to be classified as RO. The molecular weight cutoff is shown in the table above. An example of their use would be for filtering seawater to remove the salt. They are also used to remove color, fragrance and flavor from water streams.

Concentrate(18% TS), Initial Whey Feed, Permeate (From left to right)

Whey can be treated with VSEP RO to provide the highest permeate quality and reduce BOD and COD while concentrating the whey. The concentrated whey can be a marketable product and the permeate can be

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reused in the process or discharged, which can decrease or eliminate hauling costs altogether while creating a higher quality whey product.

Decreasing the volume of milk by concentrating it at the source with VSEP RO will save on transportation cost. Concentrating milk with VSEP can reduce or eliminate the use of thermal inputs used to make evaporated and condensed milk.

Nanofiltration Membranes

A great deal of recent research has led to the improvement of membranes in the range of Nanofiltration (NF). As the name suggests, these membranes are used to separate materials on the order of nanometers. These membranes are not usually rated based on their pore size because the pores are very small and difficult to measure accurately. Instead, they are rated based on the approximate molecular weight of the components that they reject or the percentage of sodium chloride or magnesium sulfate they can remove from a stream. These membranes are used predominately for wastewater treatment, but they are also used to concentrate material with a wide range of particle sizes.

Lactose in the whey can be separated from the protein with VSEP UF. The permeate can be treated in a second stage with VSEP NF to separate the salt and concentrate the lactose. To purify the lactose, the system can be operated as a diafilter to wash away the salts and impurities from the lactose, thus creating a profitable byproduct from an erstwhile waste stream.

Ultrafiltration Membranes

Conventional ultrafiltration (UF) membranes are composed of polymer material with pores ranging from a little less than 0.01 µm to 0.1 µm. These membranes are used for many different separations including: oily wastewater treatment, protein concentration, colloidal silica concentration and for the treatment of various wastewaters in the pulp & paper industry.

VSEP UF can be used to separate and concentrate the whey proteins and all suspended solids from the dissolved lactose and salts in the permeate.

VSEP membrane systems can be used to separate milk and fat to produce a consistent product and use one source for multiple products. Protein separation and standardization can also be achieved with VSEP.

Microfiltration Membranes

Microfiltration membranes are porous, with pores greater than 0.1 µm. These types of membranes are used to separate larger particulate matter from a liquid phase. Examples include concentration and separation of coarse minerals or paint particles from an aqueous solution.

Milk that has been filtered through MF membranes is called fine filtered milk. VSEP MF can also remove bacteria from milk. Thermoduric bacteria can survive pasteurization and cause milk to spoil. By removing the bacteria, the milk's shelf life is extended without removing nutrients or negatively affecting product quality

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The applications for VSEP in the dairy industry are not only limited to cheese, casein, milk, yogurt, and whey, but can also process biogas effluent, manure wastewater, groundwater, cheese brine recovery, ultra-pure water,

Originally developed for blood plasma separation, the technology has been scaled up to meet the growing separation needs for many industries. VSEP can be employed in wastewater treatment, product separations, solids dewatering or wastewater treatment. The industries and applications for VSEP are quite diversified and include: Pulp and Paper (black liquor, whitewater, box plant effluent, EOP), Industrial Water Pre-treatment and Post- treatment (ultrapure, boiler feed, surface water, RO reject), Pigments and Paint (latex emulsions, product recovery), Mining (mine tailings), Solids Dewatering (calcium carbonate, kaolin clay, TiO2), Metal Working (oily wastewater, metal hydroxides), Food and Beverage (drinking water, winery wastewater), Agricultural (biogas effluent, manure wastewater), Oil Industry (Lube oil recycling, produced water, stripped sour water) and Landfill Leachate to name a few.

For more details,
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