Journal of Environmental Management 224 (2018) 406–413

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

A review of salty waste stream management in the Australian dairy industry

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ARTICLE INFO

Keywords:
Dairy
Effluent
Salinity
Brine

ABSTRACT

Saline wastewater is a by-product of cheese manufacturing and whey processing that can have serious environmental and economic consequences. Salty streams originating from dairy processing operations include chromatography wastes, clean-in-place wastewater, acid whey, salty whey and waste generated from whey demineralization processes such as nanofiltration, electrodialysis and ion exchange. With the participation of the major dairy companies in Australia, an industry wide survey was conducted to acquire a comprehensive understanding of the management strategies for these salty waste streams. High salinity waste streams are commonly directed to evaporation ponds. However, environmental impacts from land degradation, odour and dust have prevented the construction of further evaporation ponds in some areas of Australia. The survey results also show that disposal to municipal trade waste is not always effective, as the current levels of some salinity-related parameters are significantly higher than the levels allowed by the local water/environmental authorities. For high salinity streams, salt removal can lead to more substantial savings in trade waste charges compared to wastewater volume reduction. Thus, salt removal and recovery from salty waste streams has become a major focus of the sustainability agenda of the Australian dairy industry.

1. Introduction

The $13 billion Australian dairy industry is a major exporter and the third largest rural industry in Australia (Dairy Australia, 2016). As one of the major dairy exporters to the global dairy market (Farrell and Maginnis, 2016), the Australian dairy industry encounters challenges that are largely shared by dairy processors operating across the world. Saline wastewater management is one of these challenges. Similar to the environmental concerns arising from the brine generated from industries such as seawater desalination and mining, dairy salty wastewater in Australia is subject to increasingly strict regulatory requirements due to the increase in agricultural water usage and local land degradation caused by sodium leaching (Aral et al., 2007). The origins of the saline wastewater, the current management strategies adopted by the Australian dairy industry, and the unique characteristics of these streams must be understood if suitable mitigation strategies are to be developed. This is the focus of the present paper. Importantly, an industry survey was conducted to specifically gather information about salty wastewater from Australian dairy processors. The results of this survey provide a better understanding and guidance to future research in this area.

A summary of the sources of dairy processing waste in Australia and the current mechanisms for disposal is presented in Fig. 1. This diagram represents how different waste streams can be treated in any given dairy processing facility. The generic feeds to a dairy plant are raw milk, minor ingredients, water, energy, cleaning chemicals, refrigerants and packaging materials regardless of the dairy product produced. The eventual discharge from the dairy processing boundary can be classified into three categories: wastewater, solid waste and air emissions. Wastewater is normally treated on-site or processed at a local municipal treatment station. Wastewater treated on site can be discharged for land application or again directed to the municipal sewer, depending upon the chemical characteristics and the nutrient level. Sludge generated from the onsite biological treatment and biosolids originating from wastewater separation processes (such as dissolved air flotation (Danalewich et al., 1998)) are usually dewatered before being disposed, together with other solid wastes. The dewatering flow is sent back to the water treatment process.

In general, dairy processing effluents exhibit the following characteristics (Durham and Hourigan, 2009):

- High organic load caused by the milk components;
- Variation in pH due to the presence of the cleaning agents and the process chemicals;

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https://doi.org/10.1016/j.jenvman.2018.07.056
Received 14 May 2018; Received in revised form 11 July 2018; Accepted 15 July 2018

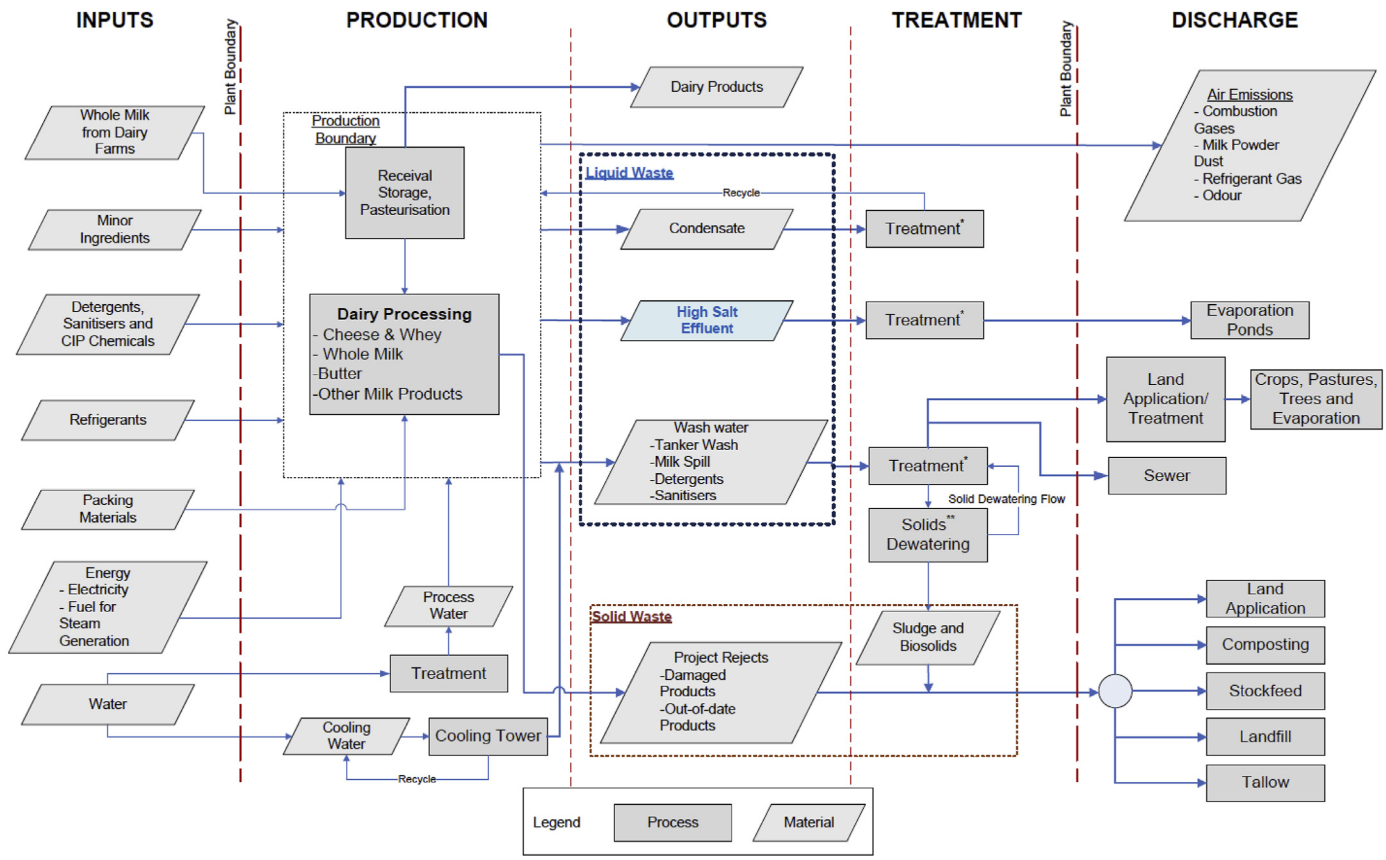

Fig. 1. A typical approach for dairy processing waste management in Australia and New Zealand (Danalewich et al., 1998; Department of the Environment Australia, 1999; Sleigh et al., 2006; United Nations Environment Programme (UNEP), 2000; Watkins and Nash, 2010; Wilkinson, 2007). * Wastewater treatments include various arrangements of standard technologies, which are not shown in detail; ** Sludge and biosolids are generated from biological treatment and wastewater separation processes such as Dissolved Air Flotation.

- High levels of phosphorus and nitrogen;
- Fluctuations in temperature.

Liquid effluent from dairy processing facilities can include high salt effluent, process condensate, cooling tower blowdown and wash water, as shown in Fig. 1. Process condensate is most likely treated separately and recycled back to the steam generation process. Wash water may contain tanker wash, milk spill, detergents and sanitisers. High salt effluent, which is the focus of this paper, is generated from a variety of sources, including whey processing, chromatographic separation and clean-in-place (CIP) processes. The volume and salinity of this wastewater is highest, however, in plants that produce hard and semi-hard cheese as their primary product. As a demand-driven and value-added product (Daufin et al., 2001), cheese production is forecast to continue to grow faster than any other dairy product in the foreseeable future, as illustrated in Fig. 2. While Australia contributes to ~2% of the global cheese production (Foreign Agricultural Service and United States Department of Agriculture (USDA), 2013), cheese making is ranked at the top of milk utilisation in Australia, with ~30% of milk being processed to more than 340,000 tonnes of cheese (Dairy Australia, 2016). Every kilogram of cheese produced creates 9 L of whey. When whey is further processed to various products, salts from the milk and the cheese-salting processes will be concentrated in the waste streams. Previous studies have shown (Aral and Sleigh, 2007; Aral et al., 2007) that over 6.7 billion litres of milk were processed in Victoria, Australia in 2007. A total of 24 factories in Victoria discharged 10 billion litres of wastewater (an average waste volume coefficient of around 1.55 L/L milk processed) and 3400 tonnes of sodium in a single year. In addition, over $20 million was spent on managing milk processing related waste.

Due to the high organic load and salinity, management strategies for these waste streams have focused on safe disposal (Trebler et al., 1938) and value-added product recovery. Over the last few decades a variety of technologies have been developed and commercialised for dairy by-product utilisation and wastewater treatment. Increasingly strict regulatory requirements have been imposed by the local environmental and water authorities, however, due to the increase in agricultural water usage and the degradation of local land. As a result, the wastewater management philosophy in the Australian dairy industry is shifting from 'treat or pay' towards 'treat or close'.

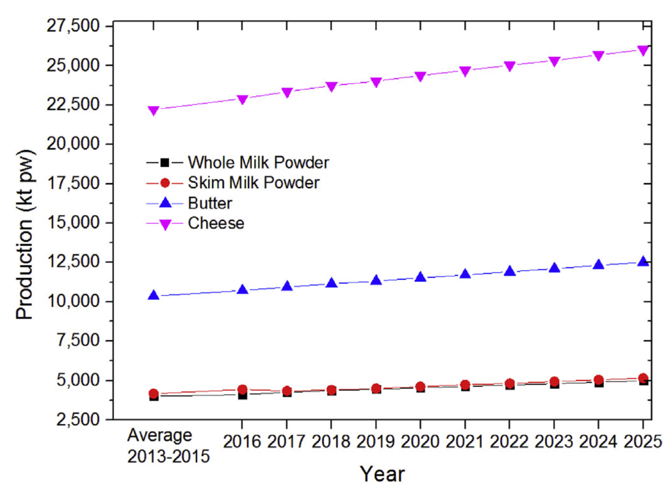

Fig. 2. World dairy projections (2016–2025). Data from the Organisation for Economic Co-operation and Development (OECD, 2016); kt pw: kilotonne per week.