INDUSTRIAL WATER USE

Project places water use of fruit and vegetable processing under the spotlight

The latest in the National Survey (NATSURV) series of reports on industrial water and wastewater management provides an update on the fruit and vegetable processing industry. Article by Sue Matthews.

Sweet treats, common condiments, pantry staples and freezer essentials – we have South Africa's fruit and vegetable processing industry to thank for providing everything from juices, preserves, purees and sauces to a variety of canned and frozen fruit and vegetables. But how well is the industry performing in terms of water and wastewater management?

A six-member team from Chris Swartz Water Utilization Engineers, Stellenbosch University's Department of Food Science and the non-profit organisation, GreenCape, recently completed a Water Research Commission (WRC) project to update the relevant NATSURV report. The original report, by Binnie & Partners in 1987, was part of a series of national surveys conducted under the auspices of the WRC and the then Department of Water Affairs (now the Department of Water and Sanitation) on the water and wastewater management of various industries in South Africa.

Given the rising cost of water, with many municipalities applying a stepped tariff based on monthly consumption, as well as water shortages experienced during periodic droughts over the intervening decades, one would expect processing facilities to have reduced their overall water consumption, or at least increased the efficiency of that consumption. A measure of the latter is the specific water intake (SWI), and while Binnie & Partners defined this as the volume of water taken in over a period per ton of raw material, the Swartz et al. report assessed the SWI in terms of both raw material and finished product.

Effluent disposal is subject to more stringent standards nowadays too, whether it be for discharge back into the natural environment, irrigation of crops or lawns, or treatment at a municipal wastewater treatment works (WWTW). Municipalities generally have limits on a range of parameters determining the effluent quality that their WWTW will accept, although these are not uniform. For example, the limit for chemical oxygen demand (COD) in Tshwane, Cape Town and Ekurhuleni is 5 000 mg/L, but 10 000 mg/L in Nelson Mandela Bay and only 3 000 mg/L in Mossel Bay. Surprisingly, effluent from food processing commonly has extremely high COD levels, often 10 to 100 times higher than those for domestic wastewater. Businesses may therefore need to pre-treat their effluent before sending it to a WWTW – or, of course, discharging it or using it for irrigation.

Fortunately, a variety of technologies for water minimisation and effluent treatment are now available, but they are still quite costly to implement. Many fruit and vegetable processing facilities do not even operate all year round, being dependent on seasonal supplies, so a lengthy pay-back period will understandably discourage investment in these technologies.

The project team's first step in assessing progress with regard to water and wastewater management was to conduct a literature review on the industry's size, nature and status, both locally and internationally. Particularly useful references included the Statistics South Africa report on the 2014 National Census data, which yielded information on the size and value of the industry, and an Optimal Agricultural Business Systems (OABS) report for the Western Cape Government's Department of Economic Development and Tourism (DEDAT). This covered the findings of a 2018 survey to assess the water risks, challenges and impacts faced by the province's agri-processing sector, and detailed how the fruit and vegetable industry had coped with the drought prevailing at the time. In addition, a guideline published by the European International Pollution Prevention and Control (IPPC) bureau in 2006 provided comprehensive background information on processing techniques and best practices in the food industry, as well as recommendations about wastewater treatment technologies.

The project team attempted to identify all facilities involved in the fruit and vegetable processing industry countrywide by acquiring membership lists from the three main industry bodies – the South African Fruit and Vegetable Canners Association (SAFVCA), the South African Fruit Juice Association (SAFJA) and Dried Fruit Technical Services (DFTS). These lists were rather outdated, though, as many of the factories had either ceased operating or had been bought out by larger corporates. Internet searchers were conducted in an attempt to resolve this, and to identify facilities that did not belong to any of the industry bodies. In all cases, contact was established with the production managers, who were considered likely to be best-informed about the main water-using operations and to have access to water management data.

An online questionnaire was then sent to these managers, containing sections on the factory's production, water usage, water minimisation efforts, wastewater generation and management, as well as energy usage. The response was relatively poor, but nevertheless yielded some valuable information. A representative sample of all the different types and sizes of facilities within the industry was subsequently visited for more detailed assessment. Unfortunately, some refused to share information they considered confidential, including water usage statistics.

Combining the data collected during these visits with that from the literature, the project team calculated the average SWI to be 6.81 m^3/ton of raw material and 8.22 m^3/ton of product for canning, 3.79 m^3/ton of raw material and 4.45 m^3/ton of product for juicing, 16.3 m^3/ton of raw material and 4.8 m^3/ton of product for freezing, and 1.3 m^3/ton of raw material and 15.0 m^3/ton of product for drying. The average SWIs for all these processing types were 6.71 m^3/ton of raw material and 7.96 m^3/ton of product.

These figures can be compared with those reported by Binnie & Partners in 1987 from the first NATSURV on the industry: 8.79 m^3/ton for canning, 1.29 m^3/ton for juicing, 14.5 m^3/ton for freezing, and an average of 9.29 m^3/ton for all the process types (drying processes were not surveyed). As mentioned previously, these were all expressed in terms of tons of raw material.

"It is encouraging that some of the facilities reported SWI figures comparable to or better than that of their international counterparts," note the project team. "In addition to this, some facilities performed well in relation to the SWIs established for certain products in the original 1987 NATSURV. Many of the facilities have dedicated long-term strategies for improving water use, with one facility in particular having almost halved water consumption over a three-year period."

The survey of effluent streams discharged from the different types of processes found average volumes of 298 m^3/d for canning, 274 m^3/d for juicing, 595 m^3/d for freezing, and an average of 407 m^3/d for the industry as a whole. This information was not available in the 1987 report, although it did provide some detail on effluent volumes and levels of COD and suspended solids for the juicing, canning and freezing of various fruits and vegetables. There was no indication that the factories surveyed back then were implementing any kind of wastewater management, but Binnie & Partners made recommendations in this regard. It mainly involved keeping solid waste out of the effluent stream in the first place, but also applying either a filtration or sedimentation step to separate out suspended solids.

These measures seem to have been taken up by the industry. The more recent survey found that most facilities perform at least one kind of primary wastewater treatment, such as screening, coarse filtering and sedimentation, sometimes followed by a neutralisation step to adjust the pH. Yet only 47% of the facilities make use of secondary treatment, which relies on microorganisms to remove suspended solids under either aerobic or anaerobic conditions. And only 16% add tertiary treatment, generally considered a 'polishing' step and involving techniques such as biological nitrification/denitrification, ammonia stripping, biological phosphate removal, membrane filtration, as well as disinfection and sterilisation.

"The lack of tertiary treatments is however expected, as it is generally only applied if previous treatments were not sufficient,"

The project team identified 82 main fruit and vegetable processing facilities in South Africa (as at 2019), their locations generally being determined by proximity to raw inputs.

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explain the project team. "The adoption of technologies may also be dependent on what is done with the final wastewater effluent. For example, facilities that discharge their effluents into municipal systems are likely to only apply primary treatments, while those that intend to reuse the water for irrigation or other processes may be more inclined to apply more extensive treatment options."

Two examples show some of the different strategies used for wastewater management in the industry. Example A processes mainly tropical fruits, with three different on-site facilities producing juice concentrates, blends, purees and fruit cubes from November to January and then individually quick-frozen (IQF) fruit pieces and canned products from March to early July. Primary wastewater treatment involves the neutralisation of pH and then physical screening before the effluent is pumped to sedimentation tanks, and eventually to a dam that serves to further separate the liquid effluent from floating solids. Secondary treatment is accomplished in anaerobic lagoons covered with tarpaulins, followed by aerobic lagoons. The final effluent is pumped into a holding dam, and then used for orchard irrigation.

Example B is a dried fruit producer, making use of tree fruit from a variety of sources to operate all year round. Wastewater management involves an initial filtration step by means of a bag filter, after which the effluent is mixed with sewage from the facility and discharged into a three-stage aerobic bioreactor. After this, the treated water is passed through a peat bed for a final filtration step. The treated water is then held in a reservoir, from which it is either discharged into the municipal system or used to irrigate the lawn. Its wastewater treatment process was reported to be able to reduce COD levels from above 4 000 mg/L to below 100 mg/L.

The report provides a good overview of all modern-day treatment technologies that could be implemented within the country's fruit and vegetable processing industry, as well measures that could be taken for improved water-wise operation within a facility or particular processes. In the final chapter, the project team point out that the catchphrase "reduce, reuse, recycle" should form part of any best-practice hierarchy for improved water and wastewater management, since reduced water consumption translates into reduced wastewater generation, while reduced chemicals use improves wastewater quality. In general, the cleaning of raw materials and facilities were found to be the main consumers of water, so these operations should be targeted for initial water-saving endeavours, providing this does not compromise food safety. Likewise, the requirement for high-quality water for food processing presents challenges when considering water recycling as a means of reducing water intake, and warrants further research.

Nevertheless, by sensitising industry stakeholders to water and wastewater issues, and providing a comprehensive guide and benchmark tool, the NATSURV 14 report is sure to achieve its main objective – to stimulate water saving and pollution mitigation by the fruit and vegetable processing industry.

To access the report, ***Natsurv 14: Water and wastewater management in the fruit and vegetable processing industry*** *Edition 2* **(WRC Report no. TT 863/21**)
click here (https://bit.ly/3LZ50RG)