Technology Investigation:
Ultrafiltration & Capacitive Deionization

Washwater treatment is a multi-stage process with a suggested defined sequence. Large solids such as vegetable pieces, tops, and culls, and aggregated soils should be removed first followed by filtration treatments. This will ensure technologies with finer filtration and treatment will not be adversely impacted by chunks clogging or blocking water flow into the system. A treatment system will be optimized once each technology filters particles within the particle size range it was designed to target. In the case of vegetable washwater, these larger particles also carry nutrients within them, thus removing solids will reduce further treatment required to achieve regulatory requirements.

Treatment systems address the sediment and nutrient load in washwater as follows: coarse solids are removed first followed by fine suspended solids, dissolved solids including soluble, and nutrients. These solids can be removed with progressively finer filtration methods whereas the dissolved nutrients must be dealt with either biological or de-ionization systems.

Ultrafiltration (UF) is a method of filtration that removes particles larger than 0.04 microns and can be used following initial settling of materials from washwater. Wastewater passes through specially designed pressurized membranes capturing unwanted material within. The membrane will need regular cleaning to prevent fouling. Some UF systems will have automatic cleaning or backwash cycles that cycle filtered water through the membrane to clear off sediment, greatly reducing the amount of maintenance required.

Capacitive deionization (CapDI) is a technology used for the removal of dissolved ions such as soluble nutrients from vegetable washwater. CapDI uses negatively and positively charged electrodes to attract and hold ions, which also have electrical charges. Negatively charged electrodes attract positive ions and the positive electrodes attract negative ions producing clear water. Each CapDI system can be designed to target different ions depending on the chemistry of the wastewater.

The HMGA Water Project tested technologies, a UF unit from Newterra and a CapDI system from Voltea, for their performance in

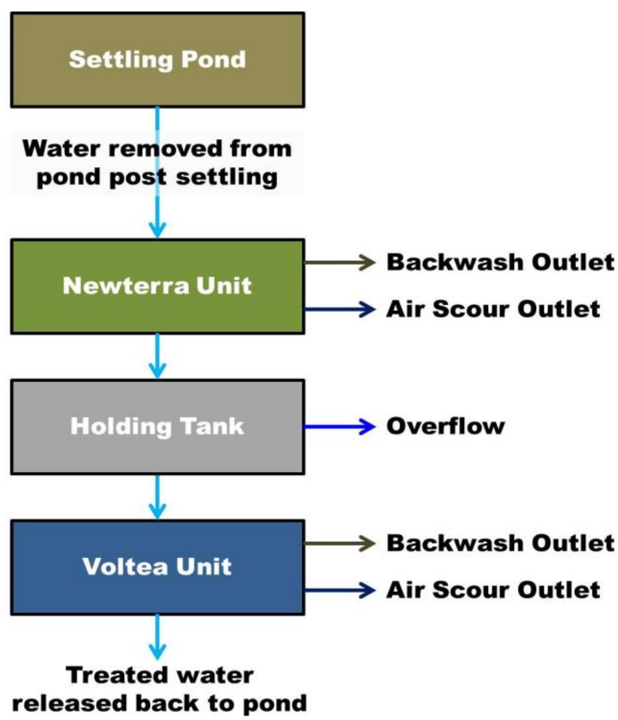

Figure 1: Ultrafiltration (Newterra) and capacitive deionization (Voltea) demonstration site organization

Figure 2: Pictures at the demonstration site; intake from settling tank (top left), UF unit (top right), UF outflow (bottom left), and CapDI unit (bottom right)

treating vegetable washwater as a secondary treatment and final polishing phase respectively. Our demonstration offered the opportunity to treat carrot and beet washwater after it had settled for 24 hours in a two stage settling pond. Water was sourced at the exit of the settling tank, passed through the UF unit, then through the CapDI unit before being returned to the settling tank (Figures 1 & 2). All waters were returned to the tank as this was a test cycle only. A holding tank was used for the demonstration in order to synchronize water flows through the two units. In full scale applications, this step would not be required. The results of the treatment were measured against provincial water quality standards and discharge quality goals for the facility.

Water samples were taken on multiple days during the test period beginning in October 2015 and ending at the end of November. Samples were secured regularly for the UF unit. The combined UF and CapDI system was tested for one day in the presence of Newterra and Voltea technicians. Samples were taken from several points to assess the efficacy of the equipment at each stage. Water exiting the washing facility and exiting the two-cell settling tank was analyzed to provide background data to later compare the efficacy of each technology based on their position in the treatment system. The UF unit water was sampled at the outflow (the treated water) and the backwash. The CapDI unit was tested at a 50% and 90% reduction in conductivity of incoming water to compare the difference

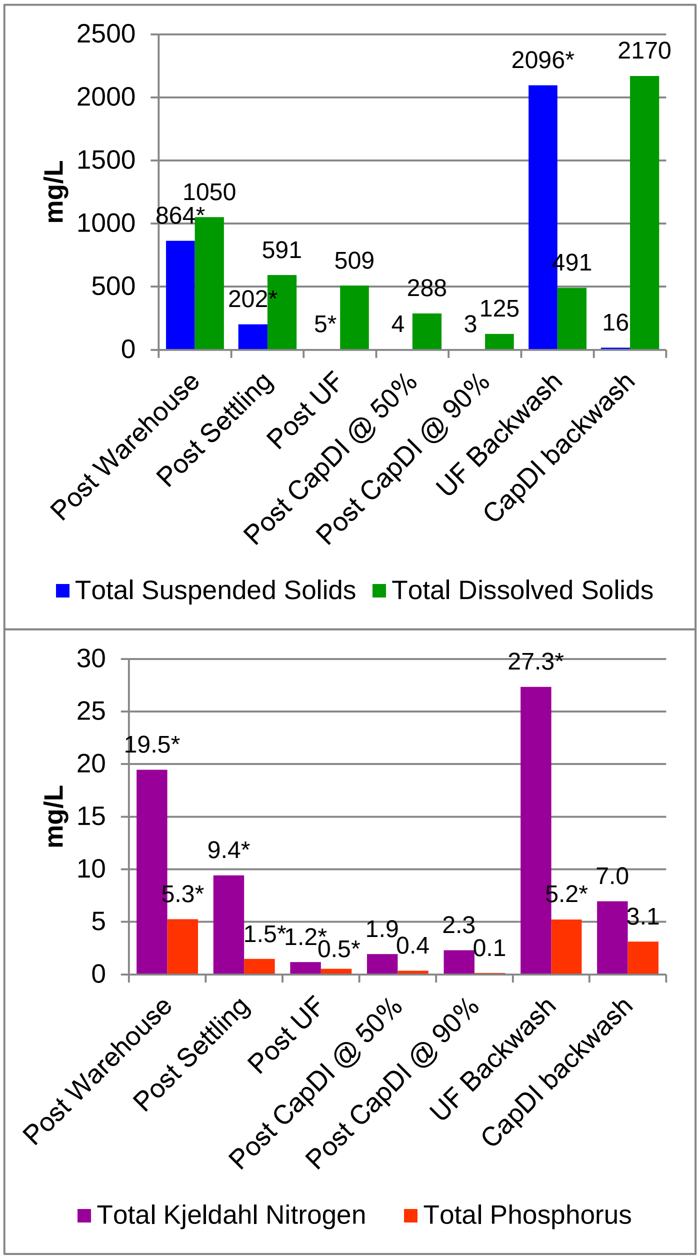

*Figure 3: Total suspended and dissolved solids concentrations (top) and total Kjeldahl nitrogen and phosphorus (bottom) at each stage of the ultrafiltration (UF) and capacitive deionization (CapDI) test with data labels. Data labels followed by * are the average of multiple sampling days whereas the rest are from one day of sampling. Discharge target levels are 35 mg/L for total suspended solids, 8 mg/L for total Kjeldahl nitrogen and 1 mg/L for total phosphorus.*

as it relates to the efficiency of the system. Samples were taken at both settings as well as its backwash. As the UF outflow was used as the CapDI inflow, no additional samples were required prior to the Voltea unit.

The results presented in Figure 3 show that the UF unit was able to reduce total suspended solids (TSS) to below the target level of 35 mg/L for discharge. The levels of total Kjeldahl nitrogen (TKN) and total phosphorus (TP) were reduced to the discharge targets of 8 and 1 mg/L respectively following the UF treatment.

The CapDI system reduced the total dissolved solids (TDS) by 43% and 75% at 50% and 90% conductivity reduction respectively. It reduced TP in a similar ratio. TKN quantifies nitrogen held in organic molecules and is not removed by this system and instead passes through.

The backwash of each unit captures and separates the water containing concentrated solids and nutrients. In regards to solid removal, UF removed mostly suspended solids with some dissolved solids whereas CapDI targeted dissolved nutrients. In regards to nutrient removal, both systems backwashed nitrogen and phosphorus out of the unit.

The test showed that a single pass through the technologies in tandem achieved the goals of washwater treatment. Levels of TSS, TKN, and TP were reduced to a point where the water could be discharged into the environment or reused in the facility. The UF outflow water could be recycled as primary washwater whereas the CapDI outflow could be further upgraded to potable water status.

Dissolved phosphorus removal was the focus of the CapDI system as an alternative to biological systems for a final water polishing phase. As the amperage of the system was increased, so was the reduction in phosphorus. The incoming water had a TP of 0.85 mg/L; the outflow had a concentration of 0.36 mg/L and 0.13 mg/L at 50% and 90% conductivity reduction respectively. The concentration of nitrogen in the outflow appeared to be negatively impacted by the emphasis on phosphorus; however, the discharged amount of TKN was still safely below discharge standards. The system can be programmed to adjust incoming washwater and outflow targets. The unit was also able to remove tannins resulting in clear beet washwater, as shown in Figure 4. As beet water is more difficult to treat, the unit's ability to deal with carrot washwater is assumed.

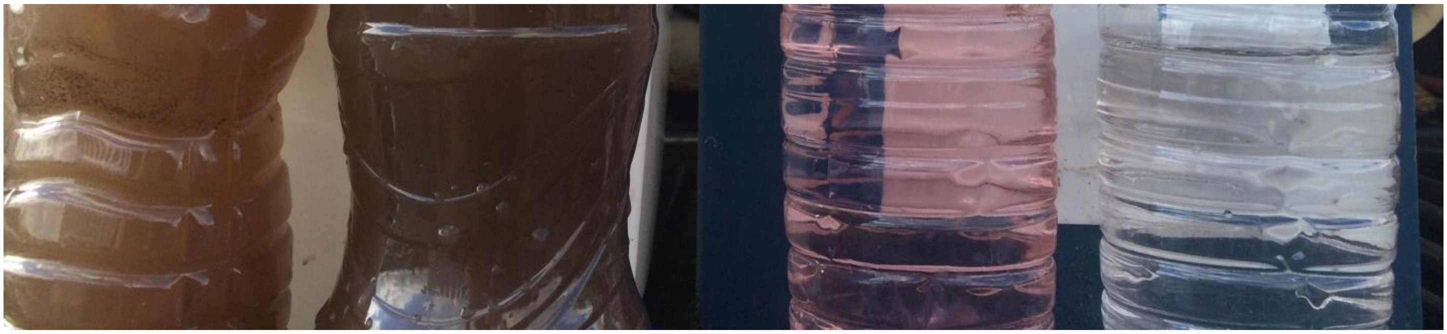

Figure 4: Water samples taken during treatment process (from left to right): beet washwater, ultrafiltration backwash, ultrafiltration outflow, and capacitive deionization outflow

Backwashing the systems produces a waste stream that will need to be handled separately before discharge. In this test, treated water was released into the same settling tank that was supplying the water for the equipment since only a fraction of the processing washwater was used and the system is still experimental for this site. This increasingly concentrated stream (Figure 4) will require either supplemental treatment at a primary stage. The UF system used a daily average of 13.9% of its treated water in the backwash system. Depending on the quality of incoming water, we observed a range of treated water amounts required with a low of 9.2% and a high of 32.1%. This points to the importance of accessing water after initial sediment removal as more pre-treatment will reduce the frequency of backwashing and increase the membrane's lifespan.

Both technologies work within an advanced water treatment system. Infrastructure is required for smooth operation. Pumps to move water through the systems need to be functioning at all times and free of debris preventing water flow. Electrical power requirements are diverse (240 and 110 amps) and necessary for different activities. Both units came equipped with an easy to use electrical box and computerized control system. They each can also function through an internet connection so that the performance could be monitored and altered remotely. The location of the equipment on the washing facility property meant a wireless connection was necessary. Voltea's CapDI has the additional option of using a SIM card. Neither technology relies on chemical additives to coagulate small particles to complete treatment. Both units are complex and require protection from the environment. They must be placed indoors or in a heated covered area to assure a minimum temperature of 4°C and a dry location not exposed to rain water. Consequently, washing operations with settling tanks away from their buildings will need to consider additional infrastructure or select the insulated containerized versions available from each company.

These systems require on-going monitoring and some maintenance to be as efficient as possible. Membranes will need to be checked on a regular basis and periodically replaced. A challenge confronting the demonstration test was a continually clogged pre-filter on the pump that supplied water to the membrane unit thereby indicating that more settling time was required before sourcing the washwater. Therefore, more sediment removal than what was achieved by the settling system at the site would be necessary prior to using this technology.

A large-scale washwater treatment system will require technologies of this nature to achieve discharge standards or recycling of the water into the washing facility. As with any system, there are challenges and costs associated with both technologies which can be overcome with the correct system set up and maintenance. Further work continues to assess implementation costs.

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