Environmental Services

Ontario Water Works Association
507 Lakeshore Rd E, Suite 215
Mississauga, ON L5G 1H9

August 28, 2020

OWWA Water Efficiency Committee,

Please accept York Region's attached application for the 2020 Water Efficiency Award for the Water Reuse Research Demonstration Project. This project demonstrates the value of treated wastewater effluent as a source of water for agriculture in Ontario. Ultimately, this Project has provided the Region with insight and better understanding of some of the technical, regulatory and environmental implications of water reuse, and positioned us to further explore the economic and societal aspects of water reuse.

I confirm the information in this application accurately represents the results from the project and can be shared on the OWWA website as part of this award.

Sincerely,

David Szeptycki
Director, Strategy and Innovation

Attachment

TMM

York-#115274555

TITLE OF PROJECT

Water Reuse Research Demonstration Project

Contact Information

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EXECUTIVE SUMMARY *100 word max*

The Water Reuse Research Demonstration project shows the benefit of shifting our perception of treated wastewater effluent from a waste product needing disposal to a resource with value. This change in perception can unlock environmental, social and economic benefits.

The project studied the use of reclaimed water (disinfected final effluent) from York Region's Mount Albert Water Resource Recovery Facility (wastewater treatment plant) to irrigate sod at an operating sod farm for a period of two growing seasons, 2018 and 2019. The study also included one season of irrigating potted hardy fall chrysanthemums and grass seed germination trials.

PROJECT PURPOSE AND OBJECTIVE

York Region (the Region) recognizes that water is a resource in all of its forms and has adopted a "One Water" approach to providing sustainable water services to its residents and businesses and is examining water reuse opportunities as part of its holistic, integrated approach to water management.

To start laying the groundwork for future water reuse opportunities, the Region undertook a water reuse research demonstration project using reclaimed water from a York Region Water Resource Recovery facility (WRRF) for non-food crop irrigation. The Project retained an academic team to undertake a two-year field study to evaluate the effects of irrigation using reclaimed water on plant health, soil properties, ground water and surface water. Findings from the study will inform broader analysis of the impact of using reclaimed water for non-food crop irrigation and other beneficial uses; and encourage policy development for reclaimed water use.

Ultimately, this Project will help the Region better understand the technical, regulatory and environmental implications of water reuse, as well as the economic and societal aspects of water reuse.

BACKGROUND

In York Region, like many places around the world, we are adjacent to a freshwater lake that is very sensitive to nutrients, particularly phosphorus and nitrogen. The nutrients enter the lake through many routes, treated wastewater effluent is one source. Although a small percentage of nutrients enter the lakes from wastewater treatment plants, it is easier to control point sources than non- point sources like run off or atmospheric deposition. Municipalities have been doing quite a good job at treating wastewater to significantly reduce phosphorus. We have been doing such a good job in York Region that in order to reduce even more phosphorus we will need to move to advanced treatment like membranes and reverse osmosis. Advanced treatment will remove more phosphorus and nitrogen but this treatment process uses considerably more energy which releases greenhouse gases into the air and is costly which will increase residents and businesses water bills. Not to mention, the nutrients removed from advanced treatment will still require some kind of disposal.

What if we used the treated effluent, or reclaimed water, where the nutrients would be beneficial? This is also known as matching water quality to an end use. This concept is a critical aspect of advanced water conservation and efficiency programs. Plants need phosphorus and nitrogen, the agriculture sector buys fertilizer with these nutrients to apply to their crops. Rather than removing these important agricultural inputs from effluent for final disposal to a receiving water body, consider changing the end use of this water to a more beneficial one.

York Region has proposed a Water Reclamation Centre in an area of planned population growth, the proposed facility will use advanced treatment to treat the water prior to being released into Lake Simcoe. If approved, the Centre has been approved to discharge highly treated effluent into Lake Simcoe through the Holland River. It will not provide approval for the use of the reclaimed water for any other purpose. Use of reclaimed water as a resource will require separate approvals from the Province of Ontario. Although reclaimed water is used around the world for non-potable use and in some cases potable use, reclaimed water for non-potable use is only occurring in Ontario on a very small scale. There are a few small private golf course condominium communities that use reclaimed water from their onsite wastewater treatment to supplement irrigation pond water. Centralized water reuse from a municipal source is new for Ontario and as such there is currently not a framework or regulation to permit use or distribution.

York Region hopes the results from this study will show the potential benefit of water reuse for agricultural irrigation in Ontario and support the Province in developing a flexible Water Reuse framework or permitting process that allows for innovation in management of our water resources in the future.

PROJECT DESCRIPTION

Reclaimed water from the Mount Albert Water Resource Recovery Facility (WRRF) was irrigated onto sod over two growing seasons (2018 and 2019; seeded fall 2017) to capture the effects of its use as an irrigation source over the typical life cycle of the crop. The sod farm is located near Keswick, Ontario. A set of control plots were irrigated using water taken from the farm irrigation pond at the same rates and times as the treatment plot. Each plot was subdivided into three sections for replicate sampling.

Additional funding obtained through the Canadian Agricultural Partnership (CAP) program and the Federation of Canadian Municipalities Green Municipal Fund allowed for two smaller studies to measure the impact of reclaimed water as an irrigation source for an alternate crop (outdoor Chrysanthemum (mum) production typical of greenhouse operations) and the impact of reclaimed water on the germination of individual grass species.

The project had incredible engagement through stakeholder workshops with the Province of Ontario Ministry of Environment, Conservation and Parks and Ministry of Agriculture, Food and Rural Affairs along with local Conservation Authorities and Agriculture and Agri-Food Canada. In particular, the Ministry of Environment, Conservation and Parks provided invaluable input from the original project scoping right through until the final report. This provided York Region with a project that would meet their needs as a regulator as well as ours. This also provided an opportunity for ongoing discussion and dialogue with the regulator regarding opportunities for municipal water reuse.

SUMMARY OF RESULTS

Approximately 165 mm of reclaimed water was applied from July to September in both 2018 and 2019 and had the following average macro- and micro- nutrient values relative to the standard annual fertilizer applications: 17% nitrogen, 55% potassium, over 100% sulphur and magnesium, and 43% boron. Ortho-phosphorus in the reclaimed water was generally below detection level; and supplied minimal P fertilizer value. The terms ortho-phosphorus, ortho-P, phosphate-P, and PO4-P are used interchangeably; this is the most readily available form of phosphorus to plants, algae or cyanobacteria (aka “blue-green algae”).

Given the very low concentration of phosphorus in the reclaimed water sourced from Mount Albert WRRF, it is likely that the reclaimed water will provide no phosphorus benefit to the irrigated crop. Due to the low phosphorus concentration, the reclaimed water also poses no threat to the environment through surface or groundwater transport. As a result, the field studies found no difference in phosphorus concentrations in groundwater between the control and the treatment areas. Irrigation with reuse water of the same characteristics as the Mount Albert final effluent would provide no phosphorus benefits to irrigated crops and would pose no threat of phosphorus enrichment to the receiving environment.

Nitrate is of potential environmental concern. Ontario’s Objective for nitrate in drinking water is 10 mg/L NO_3-N (Ontario 2006). Although the Canadian Council of Ministers of the Environment (CCME, 2012) has developed a guideline of 3 mg/L NO_3-N for protection of aquatic life it is applied to surface waters and not applied to groundwater, except were groundwater discharges to surface water. Comparative loadings of nitrate for Field Season 1 and 2 were as follows:

- The reuse water contained — 30.1 +/- 3.2 mg/L NO_3-N
- Comparative loadings for the field season were:
  - Reuse Water: — 50 kg NO_3-N/ha/yr
  - Fertilizer applied by Brouwer 2018: — 332 kg NO_3-N/ha
  - Fertilizer applied by Brouwer 2019: — 284 kg NO_3-N/ha
  - Atmospheric deposition: — 9.2 kg/ha (Winter et al. 2002[1])

Nitrate was non-detectable in all groundwater samples during the irrigation season except for one value of 0.7 mg/L measured on August 30. NO_3-N was detected at 0.097 +/- 0.56 mg/L and 0.59 +/- 0.9 mg/L

[1] Winter, J.G., P.J. Dillon, M.N. Futter, K.H. Nicholls, W.A. Scheider and L.D. Scott. 2002. Total phosphorus budgets and nitrogen loads: Lake Simcoe, Ontario (1990-1998). J. Great Lakes Res. 28: 301-314.

as N in control and treatment plots respectively in November 2018 and 0.42 mg/L and 0.73 mg/L in November 2019. All values are well below applicable guidelines. These results indicate no threats to drinking water supply from nitrate in groundwater and no threats to surface water if groundwater from the treated plots moves to surface water from reclaimed water use with the nitrate levels present in the Mount Albert WWTP effluent.

Nutrient Value Estimate – 2018 & 2019 Study Field Seasons

The reclaimed water utilized in the study contained minimal concentrations of phosphorus and the quantities of irrigation water applied, therefore added minimal amounts of phosphorus as phosphate-P to the fertility program. The table below shows the quantities of macronutrients applied to the sod over the two years of the study.

Nutrients and Ions Added Through Irrigation and Fertilizer

ANALYTE	RECLAIMED WATER 2018	RECLAIMED WATER 2019	POND WATER 2018	POND WATER 2019	FERTILIZER 2018	FERTILIZER 2019
	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
NO3-N	50	50	<0.03	<0.02	332	284
TP	<0.08	<0.09	<0.08	<0.08	11	4
K	28	30	3.4	4.2	107.2	36
Ca	157	159	31	38	1.3	0.44
S	99	102	1.2	4.3	59.8	19.84
Mg	36	39	27	25	24.9	9
B	0.28	0.29	0.15	0.16	1.3	0.44
Zn	0.09	0.04	0.01	0.005	14.9	5.0
Na	417	435	46	44	minimal	minimal
Cl	715	721	47	52	62.6	20.9

Sod production is a significant user of nitrogen. The reclaimed water did provide 50 kg/ha of nitrogen in the form of NO_3-N (nitrate nitrogen) in each year of the study. Although that is not sufficient for production, it is supplemental to the overall crop fertility program and could potentially reduce other nitrogen source requirements. The concerns growers may have included timing and leaching. Nitrate-N is water soluble, very mobile and compared to the overall nitrogen requirements of the crop, the quantity added is low. However, if added to the crop with irrigation at rates that do not result in leaching or runoff, most of it should be taken up by the crop. This represents a relatively lower risk for leaching as compared to the application of a large amount of urea fertilizer that was applied in the fall.

The fertilizer value of reclaimed water applied over the course of the study is listed in the table below. Commercial fertilizer prices are determined regionally and world-wide by supply and demand. Nitrogen, phosphorus and potash are commodities that are traded internationally, and prices fluctuate based on international supply and demand not only with respect to agricultural requirements but also with demand from other industries requiring these commodities.

Fertilizer Value Of The Reclaimed Water Used

ANALYTE	CONCENTRATION IN RECLAIMED WATER	QUANTITY APPLIED IN RECLAIMED WATER	QUANTITY AVAILABLE PER 1000 LITRES ($1M^3$)	FERTILIZER VALUE (BROWN, 2020)	FERTILIZER VALUE (BROWN, 2020)	FERTILIZER VALUE
	mg/l	kg/ha	kg/1000 L	$/kg	$ / 1000 L	$/ha/yr
NO_3-N	29.96	50	0.02996	1.07	0.032	53.50
Total P	< 0.083	< 0.09	<0.000083	0.95	0.00008	0.08
Potassium	16.96	29	0.01696	0.65	0.011	18.85
Sulphur	60.88	100	0.06088	2.20	0.13	220.00
Fertilizer Value per 1000L ($1m^3$)					**$ 0.18**	
Fertilizer Value per hectare per year						**$ 292.43**

The very low phosphorus concentration in the reclaimed water resulted in essentially no value to P fertilization. The data shows some fertility value from the nitrogen and potassium additions through the reclaimed water applications and a grower could potentially reduce commercial fertilizer applications based on these values.

Pharmaceutical and Personal Care Products (PPCP) and PFAS Test Results

Reclaimed water and groundwater samples were taken July (pre-irrigation), August, September, and November in 2018 and June (pre-irrigation), July, August, October and November in 2019. They were submitted to the Ministry of Environment, Conservation and Parks (MECP) laboratories for analysis of a variety of pharmaceutical and personal care products (PPCPs) and perfluoroalky and polyfluoroalkyl substances (PFAS). The results for the two field seasons appear similar.

- The PPCP analyses consistently showed DEET and Oxybenzone (sunscreen) in the reclaimed water, groundwater and pond water. Several other PPCPs were detected in the reclaimed water and a few occasionally at very low levels in groundwater, but no obvious patterns were seen in the remainder of the results and no apparent link to the reclaimed water.
- PFAS were detected more frequently in 2019 than in 2018 but this was likely due to an increased sensitivity in the testing at the laboratory resulting in a reduction in the detection limits for the methodology. As a result, several PFAS species were detected in the 2019 irrigation pond water and groundwater under both control and treatment plots, as well as tile water from the field above the plots.

Greenhouse Gas Implications

The Greenhouse Gas Inventory Survey Carbon Footprint, prepared during the study and design of the proposed Water Reclamation Centre (WRC) (Black & Veatch and GHD, 2015), discussed the GHG emissions from the proposed Water Reclamation Centre. The inventory accounted for direct emissions such as burning of natural gas, vehicle transport emissions, process equipment emissions, chemical usage emissions, solids transportation emissions and off-site solids decomposition emissions; indirect emissions such as operating staff commuting and biogas; and emissions associated with electricity use. The inventory found that at full operation, treating 40 MLD of effluent for surface discharge, one year of Water Reclamation Centre operation would result in emissions of 8.9 million kg CO_{2e} (Black & Veatch and GHD, 2015).

As a high-level comparison between surface discharge and reclaimed water production at the proposed Water Reclamation Centre, the greenhouse gas implications of producing 5 MLD of reclaimed water instead treating 5 MLD for surface discharge were estimated. The difference in greenhouse gas emissions was assumed to result from the avoided electrical usage of advanced treatment (reverse osmosis) in the surface discharge treatment train. Based on figures from the National Inventory Report: Greenhouse Gas Sources and Sinks in Canada it was assumed that electricity had a greenhouse gas impact of 40 g CO_{2e}/kWh (Environment and Climate Change Canada, 2017). Using an updated electrical load for the reverse osmosis system (Wu, 2020), it was estimated that over a 90-day growing season, the proposed Water Reclamation Centre could avoid 117,000 kg CO_{2e} by treating 5 MLD for reclaimed water use rather than discharge to surface water.

Based on the estimated fertilizer savings it was estimated that approximately 517 kg CO_{2e} could be avoided by replacing synthetic nitrogen, phosphorus and potassium fertilizers with nutrients from 5MLD of nutrient rich reclaimed water, over a 90-day growing season (Jayasundara, Wagner-Riddle, Dias, & Kariyapperuma, 2014). This equates to 0.1 kg CO_{2e} avoided per m^3 of reclaimed water used.

CONCLUSION

The Water Reuse Research Demonstration Project is advancing municipal water reuse in Ontario. It demonstrated the safety and value of reusing municipal water for agricultural irrigation. This project has improved the understanding and implications of centralized water reuse for York Region and the Province of Ontario. Water Reuse from a municipal source can unlock many benefits such as reduced nutrients into our water ways and reduced greenhouse gases due to advanced treatment. Ultimately water reuse can match water quality to its end users need, therefore reducing the need for fresh and potable water supplies in the future.