ECONSE Water Purification Systems Inc.
1305 Morningside Ave, Unit 12 & 13
Scarborough, ON, Canada, M1B 4Z5
1-416-606-5014 info@econse.com

Activity 5: Safer Water Inputs

Executive Summary

Safer Water Inputs

Many traditional water treatment technologies exist to address water potability, or disinfection. However, in-field options to reduce pathogens from canal water prior to irrigation are limited. Growing urbanization near agricultural activities are impacting water quality during a time when irrigation practices are increasing due to the effects of climate change. Together the risk to public health and financial fall out from product recalls make the need for new solutions urgent

Econse is a Canadian manufacturer of decentralized water and wastewater treatment solutions. Our technologies are helping Farms, Greenhouses, Producers and Agricultural Businesses address their unique water related challenges including, end of pipe treatment, water recycling systems and disinfection tools.

In early 2020, Our engineering team, in partnership with the University of Waterloo's Institute for Nanotechnology, began validating our new technology for improved disinfection across a variety of applications.

This new technology has the potential to be deployed as a powerful tool for in-field disinfection, while providing safer water and safe products from Canadian Farms.

We gratefully thank the Holland Marsh Growers Association, Ontario Ministry of Agriculture and Rural Affairs for the opportunity to demonstrate our new technology.

Regards,
Derek Davy, CEO Econse

ECONSE Water Purification Systems Inc.
1305 Morningside Ave, Unit 12 & 13
Scarborough, ON, Canada, M1B 4Z5
1-416-606-5014 info@econse.com

Purpose of study

This study was carried out in partnership with Holland Marsh Growers Association and Econse Water Purification Systems Inc. with additional support from Muck Crop Research Station of the University of Guelph.

The purpose of this study was to measure seasonal levels of E.coli in canal water and to investigate and demonstrate new technology for reducing E.coli levels in waters intended for vegetable crop irrigation. The treatment target was set by Holland Marsh Growers Association for a goal of Log 1 (90%) reduction in E.coli using a feasible and scalable process suitable for their farms irrigation needs.

Background on Issue

As a result of growing urbanization near farmland, decreasing water quality due to climate change (floods and drought), source water may have increased presence of E. coli and other pathogens to levels not previously seen. Irrigation practices are increasing across Canada, while source water quality is measurably affected by climate change, urbanization, dry conditions, and rapid flooding.

Historically, not all crops were irrigated, but as of 2021 a wider number of crops are irrigated for longer periods of time than traditional models suggest. Poor water quality may require disinfection of irrigation water to reduce the risk of E.coli, and other emerging water borne pathogens, to help protect public health and decrease the frequency of product recalls.

However, disinfection of irrigation water is not a common practice due to significant challenges in feasibility if using traditional treatment technology such as UV, OZONE or Chlorine. In the case of canal-based irrigation of agricultural crops, this step may be necessary to reduce E. coli, if the source water has pathogens of a level that may lead to health concerns for humans, if consumed. This is usually an issue in produce such as leafy greens, celery, broccoli, and some fruit. As this is an emerging area of study, high levels of E. coli in irrigation water may be a concern for other crops too.

Disinfection Technology

Many water treatment technologies exist to address water potability. However, “in-field” options to reduce pathogens prior to irrigation are limited.

This project looked at a variety of traditional technologies contrasted them to new alternative solutions to ease adoption by reducing Capex, Opex and improve treatment results to optimize for crop health and provide safer options for irrigation practices.

A report summarizing the various disinfection technologies (Chlorination; Ultraviolet Light UV; Ozone; Econse Ozocav) has been updated and included at the end of this report.

See Appendix A: Safer Water Inputs Disinfection Technology Summary

As mentioned in the report, many commercially available technologies present design and operation challenges for effective disinfection of canal water on a scale useful for irrigation. Because of this, Econse developed and adapted their OZOCAV Technology to provide a new tool that may provide effective, affordable disinfection for irrigation.

The OZOCAV technology utilizes a powerful disinfection agent (ozone) dissolved in solution (water) producing highly oxidized nanobubbles without the use of any consumable chemicals. Contact time is significantly faster than traditional chemical disinfectants (<1min). After application the disinfecting agent reverts to water and oxygen which eliminate any toxic environmental by-products and limits exposure to harmful chemicals for workers.

During the project the pilot size unit was scaled up to demonstration size for initial field trials.


Photo 2 Left: Econse technician using pilot scale unit with canal water.
Photo 3 Right: Initial field trials testing unit at full scale.

	PRO	CON
OZOCAV System	• Chemical Free • >99% (Log 1) disinfection • Easy to retrofit to pumps • No operator required	• Any new technology requires demonstration and adoption by Farmers
	Capital Cost:	Operation Cost:
	Medium – Equipment, retro fit to existing irrigation pump	Low – uses ambient air, and power supplied by Irrigation Pump generator (alternator)

Table 1: Summary of Ozocav Technology
Source: *Appendix A: Safer Water Inputs Disinfection Technology Summary OZOCAV*

ECONSE Water Purification Systems Inc.
1305 Morningside Ave, Unit 12 & 13
Scarborough, ON, Canada, M1B 4Z5
1-416-606-5014   info@econse.com

Environmental Findings

Samples were collected from identified locations throughout the Holland Marsh canal and pumphouse on a scheduled basis to get a baseline of seasonal changes in water quality. The sampling showed a wide variety of concentrations of both E.coli, Turbidity, Nutrients, Phosphorus and BOD. The results confirm that the levels of E.coli present were higher than originally estimate of <10 CFU/100mL.

The findings on E.coli levels show that it is difficult to predict presence or assume concentration of E.coli in source water. This may lead to farmers using water which is highly contaminated without their knowledge.

Please see attached files for full reports (appendix)

- Sample "K": E Holland River near 860 Edward Avenue King, ON L3Y 4V9 Canada
- Sample "H": N Canal water near 1383 River Rd, Bradford, ON
- Sample "P": Art Janse Pump Station 600 Pump House Rd, Bradford, ON L3Z 1A1
- Sample "SC": South Canal - E Holland River near 860 Edward Avenue King,
- Sample "NC": North Canal - water near 1383 River Rd, Bradford, ON
- Sample "PH": Pump house - Art Janse Pump Station 600 Pump House Rd, Bradford,
- At each of the sites, 3 samples were taken to understand changes due to water flow.
- Samples were numbered sequentially 1, 2, 3.
- An average of results were summarized below:

Physical Tests (Water)	AVERAGE	LOW	HIGH
Turbidity NTU	32.23	12.7	130
Anions and Nutrients (Water)	0.37	<0.022	0.668
Nitrate (as N)	0.31	<0.020	0.631
Nitrite (as N)	0.06	<0.010	0.087
Total Kjeldahl Nitrogen	7.6	2.07	23
Total Nitrogen	7.88	2.75	23
Orthophosphate-Dissolved (as P)	0.39	<0.0030	0.69
Phosphorus, Total	1.45	0.148	4.63
Bacteriological Tests (Water)			
E. Coli CFU/100mL	70.44	0	500
Aggregate Organics (Water)			
BOD mg/L	33.94	<3.0	167

Table 2: Summary of results from canal sampling
Source: Appendix B: 3rd party Lab Results Summary

Field Trials and Findings

Samples from the pumphouse represented the highest levels of E.coli and as such we used this as source water for our final treatment testing. Due to limited infrastructure near pumphouse. 1000L batch samples were taken to facility for treatment and analysis.

Date	ORP (mv)	DO (ppm)	DO %	E.Coli (mg/l)	Notes:
2021-08-17	1	4.5	54.1	300	Collected at canal
2021-08-17	13	2.4	26.2	430	Start
2021-08-17	145	6.71	81.3	12	Finish

Table 3 Final Results (Temperature was approximately 20C)
Source: Appendix B: 3rd party Lab Results Summary

The results indicate >1 Log removal (>90%) and significant improvement in dissolved oxygen levels (DO). In full scale irrigation, this would improve crop health and decrease risk of E.coli presence in irrigation water to reduce frequency of product recalls from source water issues.

Photo 4: Source Water for final test 2021-08-17 Art Jansen Pumphouse, Bradford, Ont.

Conclusions and Next Steps

The study discovered the presence of E.coli and other contaminants in source water varies greatly and may be present in levels higher than expected. This poses a risk to farmers using source water for irrigation of crops intended for human consumption.

The true cost of a product recall vs. the cost of mitigating risks is difficult to calculate. As the frequency and scale of recalls occur due to poor quality of water and presence of waterborne pathogens in irrigation water increases, the need for affordable, effective and reliable treatment options increases. The demonstration project showed the potential of Econse OZOCAV technology to improve water quality and reduce levels of E.coli in field side irrigation.

In this study we focused on E.coli as it is a well documented risk for food crops, such as leafy greens, celery and crops that can be eaten without washing or cooking. Questions still remain regarding what risks are posed to crops are using irrigation water. As this is an emerging area of study, many questions around other water born pathogens were not investigated at this time, but could be studied in the future. If through the use of disinfection equipment, the frequency of recalls can be reduced, and public health risk decreased, then the cost of treatment may be justified. We do not yet know the degree of risk posed by urbanization near farm lands, climate change, floods and drought on the level of E.coli and other water born pathogens, but we assume these trends pose new challenges for agricultural operations and new responsibilities for farmers.

Econse is helping farmers manage their environmental footprint and adopt sustainable business practices with our decentralized, closed-loop wash-water treatment systems. A single unit can reduce daily water uses by $1/1000^{th}$ and divert all effluent from vegetable washing from entering the environment, thus reducing E.coli and Phosphorus and improving overall water quality. When used in conjunction with our disinfection technology for irrigation, the farmers will be able to become better stewards of their lands and water, preserving it for future generations and ensuring safer quality food products for Canada.

The work accomplished in 2021 could be further scaled up to follow 3 farms for a complete crop year where ECONSE would provide a scaled up system and technician to monitor operational performance.

ECONSE would also propose to demonstrate our technology to reduce spoilage in stored vegetables from pathogens, mold and fungus. The treatment would be evaluated and benchmarked against another facility with no treatment. The reduction in vegetable spoilage could be quantified after 2 and 4 months of storage.

Thank you and Regards,
Derek Davy, CEO Econse
Report Prepared by: Andrew Amiri, Derek Davy, Neil Sosebee

Appendix A: Safer Water Inputs Disinfection Technology Summary

2021-06-01 (UPDATED 2022-02-15)
Report by: Derek Davy, CEO Econse
For: Charles Lalonde, Holland Marsh Growers Association

Many commercially available technologies are suffering from low disinfection effectiveness, operation challenges, scalability and sustainability for effective disinfection of canal water on a scale useful for irrigation. Because of this, Econse has developed and adapted their OZOCAV Technology to provide a new tool that may provide effective, affordable disinfection for irrigation water.
Please see the following summary of available disinfection technologies:

- Chlorination Disinfection
- UV-Disinfection
- Ozonation-Disinfection
- Econse: Ozocav Disinfection

In this document, we (Econse) will compare various commercial disinfectant systems as supplied by the HMGA for their efficacy as used for disinfection of canal water to be used in irrigation of crops. We will also contrast these technologies to our OZOCAV technology.
Comparison of Commercial Disinfection Approaches for Irrigation:

In water treatment, disinfection refers to the killing or deactivation of pathogens, microorganisms (e.g., E. coli) and viruses that are present in the water to an acceptable level.

In the case of canal-based irrigation of agricultural crops, this step may be necessary to reduce E. coli, if the source water has pathogens of a level that may lead to health concerns for humans, if consumed. This is usually an issue in produce such as leafy greens, celery, and some fruit.

Irrigation practices are increasing in areas experiencing increasingly dry conditions, which may also affect source water quality, and increase pathogens to levels not traditionally seen. As this is an emerging area of study, high levels of E. coli in irrigation water may be a concern for other crops too.

In the Holland Marsh Growers Association (HMGA) Vegetable and Fruit Washwater Manual (Publication 854, 2017), Section 8.9 deals with Disinfection Technologies evaluated by HMGA. These include 3 commercially available technologies:

Chlorine
Ultraviolet Light (UV)
Ozone

Each of these tools have an ideal performance range and are intended for specific applications. A water treatment engineer is able to advise in the selection of the appropriate technology based on the specific end use. When the end use is for canal-based irrigation of agricultural crops, each of these 3 known technologies presents specific design challenges.

Chlorination Disinfection

Chlorination is a relatively effective oxidizing technology for killing and deactivation of E.Coli, but is a chemical consumable and a salt, making its use very limited for large scale application.
Advantages:

- Chlorine can achieve 90% (Log 1) removal of E.Coli with 10 mins CT in clean water having no organic contamination, TSS...etc.
- Chlorination disinfection is a Low Capital Investment Technology,

Disadvantages:

- Less effective at presence of organic Material, TSS and TDS such as canal water
- Reduces culturable not viable E.Coli of ag.water by 0.2-0.3 log (present of Organics)
- Minimum 10min contact time at proper dose
- Reduce crops yield by reducing photosynthesis capability of leafy vegetables
- Add toxic HHA and THM By-Chlorination Products (CBPs) to soil and to ground water
- Biological impact on health of soils' microbiome
- Increases salinity of soil
- Very difficult estimation of contact time (CT) and dosing in contaminated water

UV-Disinfection

To work, the UV light must reach the organism in the water. Any contamination that blocks the light may decrease the effectiveness of disinfection; therefore, particles should be filtered from the water before it passes through the UV treatment unit. UV light water-disinfection offers many benefits, but a few drawbacks make it impractical technology for disinfection of surface water like Holland Marsh Canal Water from E.coli. For UV disinfection to be effective, the water quality should meet the minimum limits as set by the manufacturer or the following parameters:

Advantages:

- UV Light disinfection can achieve 90% (Log 1) removal of E.Coli in seconds (CT-time) for water without turbidity, Organic and inorganic Material (TSS and TDS), at proper light intensity.
- UV technology create no disinfection by-product

Disadvantages:

- Less effective in high turbidity (Turbidity should be below 1.0 NTU)
- Looses effectiveness when organic Material, TSS and TDS in water
- Need pre-filtration process to reduce blocking contaminations
- Reduces culturable not viable E.Coli of agricultural water by 0.2-0.3 log
- High Capital Investment specially in high volume surface water disinfection
- High Operation Cost in need of skilled worker

Ozonation-Disinfection

Ozone gas is a strong chemically active oxidation agent, with capability in deactivation and disinfection water from pathogens, but the Conventional Ozonation Technology has few draw back properties which makes it impractical for disinfection of surface water for irrigation applications.

Large volume of gas required for effective disinfection of pathogens in surface water (energy intensive). There are three major functional behaviour behind technological failure of Conventional Ozonation Disinfection of surface water:

1. Micro and Macro bubbles amalgamate and move to surface by bouncy effect (waste of gas) before contacting the pathogens in water.
2. Small contact surface of the sum of generated micro and macro bubbles in conventional technology
3. Lack of the synergy of gas stability, increased life span and large contact surface of bubbles stops the technology to accomplish deactivation of pathogens.

Advantages:

- Effective disinfectant with strong 2.07 eV Oxidation potential (Chlorine 1.36 eV)
- Shorter treatment compared to chlorine for similar water contamination
- Less dependent on pH than chlorine
- Improves quality of wastewater in terms of colour , odour, turbidity and dissolved oxygen
- Residual ozone is toxic but the residual disappears quickly in the receiving stream

Disadvantages:

- The effectiveness has been limited because of its relatively low solubility in water (0.64 g/100ml at O° C) and rapid decomposition in aqueous phase
- Amalgamation of large bubbles causing waste of gas out of liquid due to buoyancy effect
- Small reactive contact surface due to large bubble sizes
- The efficacy of Conventional Ozone Disinfection is limited as it is unstable in water.
- Conventional Ozone Solution requires high contact time (20-30 minutes) when water contaminated with Organic material, TSS and TDS.
- The technology generate residual ozone gas if not quenched harmful for humans
- Difficult estimation of destructive contact time with pathogens in traditional approach
- High Operation cost due to extreme waste of gas
- High possibility of destruction of material surfaces by using traditional approach

ECONSE Water Purification Systems Inc.
1305 Morningside Ave, Unit 12 & 13
Scarborough, ON, Canada, M1B 4Z5
1-416-606-5014 info@econse.com

Econse – Ozocav Disinfection Technology

The presence of organic matter in canal water, and turbidity can have a negative impact on the effectiveness of any disinfection technology and potentially reduce their effectiveness.
Econse developed the OZOCAV technology to help improve disinfection power in a simple, robust system to allow for canal-based irrigation in high volumes, regardless of fluctuating water qualities.

Econse is a Canadian manufacturer of decentralized water and wastewater treatment solutions. Our technologies are helping Farms, Greenhouses, Producers and Agricultural Businesses address their unique water related challenges including, end of pipe treatment, water recycling systems and disinfection tools.

In early 2020, Our engineering team, in partnership with the University of Waterloo's Institute for Nanotechnology, began showcasing a new technology allowing for improved disinfection across a variety of applications.

The technology utilizes a powerful oxidizing agent (ozone) dissolved in solution (water) and applied to the area or liquid requiring disinfection without the use of any consumable chemical. Contact time is significantly faster than traditional chemical disinfectants (<1min). After application the disinfecting agent reverts to water and oxygen which eliminate any toxic environmental by-products and limits exposure to harmful chemicals for workers.

Initial trials with the University of Waterloo show a powerful disinfection effect (>log 5) against E. coli and total coliforms. A white paper will be published in 2022. Our technology can also disinfect Bacteria, Viruses, Pathogens, Microbes, Mould, Fungus. Further study on its effects on specific pests and improvement to soil health will be evaluated later in 2021.

This new technology has the potential to be deployed as a powerful tool in irrigation disinfection, and potentially will improve crop quality by increasing dissolved oxygen content of irrigation water, while providing safer working conditions on farms for workers, suppliers, and producers.

Our 3D printed reactor is highly unique with respect to exposing water particles to ozone and is highly scalable and allows us to provide disinfection to large flows of water. For this application, we will retrofit our unit into any existing irrigation pumps with a simple coupling to treat water in parallel and return to the irrigation system. Water will be disinfected in real time to achieve the desired result (i.e., Log 1 or 2 removal) and injected into the irrigation feed for application to crops.

This novel approach will eliminate any need for consumable chemicals, or large contact vessels, and will disinfect regardless of the turbidity. The system is small and compact, and our low power requirement can be supplied by the Pump's generator.

The technology combines powerful destruction energy of cavitation along with powerful disinfection agents such as O_2, O_3, and $_{0}OH^{-}$ Free radicals in the form of Micro Nano Bubbles (MNBs) dissolved in water solution producing a combined oxidation effect without using any consumable chemicals.

Ozocav disinfection contact time (CT) is significantly faster than traditional technologies due to several fundamental advancements that became possible through our technology.

Advantages:

- Highly efficient disinfection technology for all types of microorganisms in the market with combined oxidation agents: Hydroxyl Radical, Atomic Oxygen, Ozone gas, and Oxygen molecule (see the potential table 1).
- Increasing crops yield by rising dissolved oxygen (DO) and Dissolved Nitrogen (DN) levels in irrigation water
- Technology capable of coping with variable level of organic matters, pathogens, turbidity, TSS, TDS, pesticide and herbicide in canal water.
- Highly efficient disinfection technology (validated by UOW-IONT) Effective for deactivation of E.coli and other pathogens
- Functional and productive technology at any water pH and seasonal temperature.
- Improves soil biology and health of microbiome by adding Oxygen and Nitrogen
- Requires no skilled labour for operation (sturdy mechanical design)
- Shortest CT time in the industry due to existence of combined oxidative agents
- Improves quality of water in terms of colour , odour, turbidity and dissolved oxygen
- No toxic residual of ozone discharged causing humans H&S or toxic for soil health.

Disadvantages:

- New Technology adoption is difficult into markets
- Can produce Formaldehyde, Aldehyde, Hydrogen Peroxide, and Bromomethanes when used in very low doses of O3-MNBs and when Bromide is in water *****
- Very high solubility in water (depending on nano-size) and stable in aqueous phase

Ozocav- CCOO Combined Cavitation Oxidation Ozonation Disinfection agents in water	
Oxidative Agents	eV
Hydroxyl Radical	2.8
Atomic Oxygen	2.42
Ozone	2.07
Hydrogen Peroxide	1.78
Oxygen molecule	1.26

Table 4 Oxidation Agents

Appendix B: 3rd Party Lab Results

Please see attached excel files for source report of lab results:

- 2021_08_Appendix B 3rd Party Lab Results All.xlxs
- 2021_08_L2628226_XLR.xlxs
- 2021_07_L2615117_XLR_Full.xlxs
- 2021_06__L2600086_XLR-2.xlxs
- 2021_02__L2561576_XLR-2.xlxs

Appendix C: University of Waterloo Institute for Nano Technology Ozocav Results

See following page for summary of results

UNIVERSITY OF WATERLOO | WATERLOO INSTITUTE FOR nanotechnology

WATERLOO INSTITUTE FOR NANOTECHNOLOGY
Dr. Sushanta Mitra, P.Eng.,
FASME, FCSME, FEIC, FRSC, FCAE, FAPS, FAAAS
Executive Director
519-888-4567, ext. 37176 | skmitra@uwaterloo.ca
nano.uwaterloo.ca | uwaterloo.ca/mntl

Appendix C: University of Waterloo Institute for Nanotechnology Ozocav Results
Econse Project Update
Date: January 29, 2021: Prepared by: Sirshendu Misra & Sushanta Mitra, University of Waterloo

Our test results targeted as assessing the antibacterial efficacy of Ozocav indicate that the ozonized discharge effectively kills all the bacteria in the solution below a threshold CFU/ml of E. coli in the sample. We have started with a concentrated bacterial stock (grown in Lauryl Tryptose broth) with a bacterial concentration of 31 M CFU/ml and serially diluted the stock by a factor of 10 at each step to obtain bacterial solutions with sequentially lower concentrations. 500 µl of bacterial solution at each concentration were then mixed individually with 10 ml of Ozocav discharge
(ORP level: 826 mv, 31.9o C).

Once they are thoroughly mixed and allowed to stay in contact for at least 10 minutes, the resulting treated solutions were checked for bacterial growth by three methods – subculturing in a nutrient broth (Lauryl Tryptose), plate counting on Luria-Bertani Agar and detection of presence/absence using a reagent (Colisure) that turns magenta from yellow and fluoresces upon incubation even if there is only 1 organism of E. coli is present in 1 ml of solution.

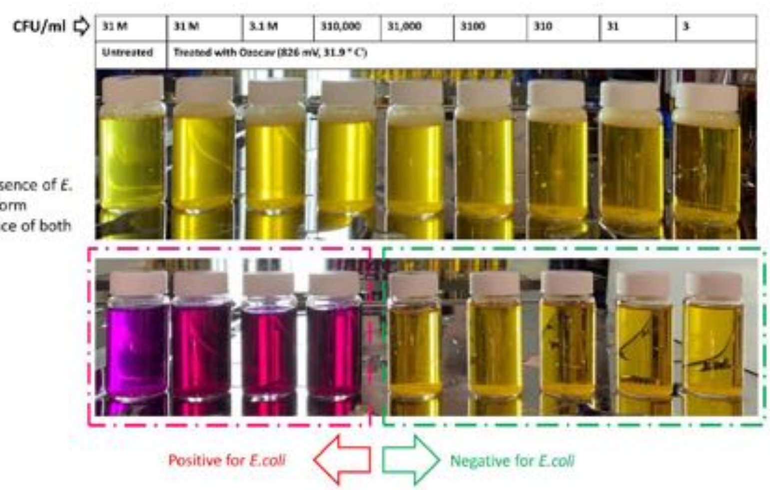

Figure 1: Effect of Ozocav treatment on bacterial solutions with different concentration (CFU/ml). Ozocav treatment, as outlined above, successfully eliminated all the bacteria from the solution for a CFU level 31,000 CFU/ ml (3.1 M CFU/100 ml) and below.

The conclusion from application perspective is that below 3.1 M CFU/100 ml bacterial concentration, Ozocav could effectively eliminate all the bacteria in sample solution (non-detect on agar plate).

QNC, 200 UNIVERSITY AVENUE WEST, WATERLOO, ON, CANADA N2L 3G1