WCWC Walkerton Clean Water Centre
An agency of the Government of Ontario

CWAE Centre de Walkerton pour l'assainissement de l'eau
Un organisme du gouvernement de l'Ontario

Pilot Testing Project Report:

Colgan Drinking Water System Bench-Scale Study

Walkerton Clean Water Centre

Research & Technology

July 15, 2021

Disclaimer

The pilot testing project report is presented solely for information purposes and is not intended to provide specific advice or recommendations in any circumstances. This pilot testing project report includes information from different sources and such information has not been independently confirmed for correctness or completeness. The information provided does not imply on the part of the Government of Ontario, the Walkerton Clean Water Centre (Centre) or its employees, any endorsement or guarantee of any of the information. The Government of Ontario, the Centre and its employees, do not assume and are not responsible for any liability whatsoever for any information, interpretation, comments or opinions expressed in the pilot testing project report.

Executive Summary

Background

A drinking water system in southern Ontario currently provides water to a population of 232 people. Developments have been proposed that would increase the total population to approximately 2,800.

The current detention time in the distribution system is approximately two days. The proposed design changes will result in an increased storage volume and water age, potentially as high as 20–30 days during early stages of development. The increased water age will likely lead to increased levels of disinfection by-products (DBPs) including trihalomethanes (THMs) and haloacetic acids (HAAs). Ontario Drinking Water Quality Standards (O. Reg. 169/03) define the maximum acceptable concentration (MAC) of THMs in treated water as 100 µg/L, and HAAs as 80 µg/L, based on a running annual average of quarterly samples.

Sodium silicate is used to sequester iron and manganese present in the raw water. An additional concern is that the increased water age will allow iron and manganese to come out of solution.

Objectives

The objectives of this bench-scale study were to:

1) conduct a chlorine decay test on the treated water from the drinking water system;
2) conduct a simulated distribution system (SDS) test for the potential formation of THMs and HAAs; and
3) monitor general water quality and identify potential issues including aesthetic monitoring for iron and manganese that may come out of sequestration.

Approach

Samples of raw water and treated water were collected on-site at the drinking water system during two visits. For Chlorine Decay Test 1, raw and treated water were analyzed on-site and in intervals throughout the study to determine the concentrations of chlorine (free and total residuals) and silica (from the sodium silicate) remaining over the 20-day detention time along with other water quality parameters. These values were used to assess chlorine dose requirements for Chlorine Decay Test 2.

Chlorine Decay Test 2 was conducted in duplicate, using the chlorine dose determined from Chlorine Decay Test 1. SDS tests were completed with the water from Chlorine Decay Test 2, using the proposed detention times for the upgraded drinking water system to assess DBPs formation potential. Samples for both THMs and HAAs were collected and sent to an accredited external laboratory.

Key Findings

Key findings of this study are as follows:

1) The chlorine demand was an average of 0.63 mg/L over 20 days.
2) The highest level of THMs recorded during the SDS tests was 23.5 µg/L on Day 20, which is well below the MAC of 100 µg/L.
3) The highest level of HAAs recorded during the SDS tests was 6.7 µg/L on Day 17, which is well below the MAC of 80 µg/L.
4) Sequestration of manganese appears to be working, however dissolved manganese levels reduced from 0.033 mg/L on Day 0 to 0.007 mg/L on Day 20. Iron came out of solution during transportation and could not accurately be assessed.
5) Apparent colour was consistently above the aesthetic objective (AO) of > 5 Pt-Co in all samples on and after 10 days of detention.

Table of Contents

List of Tables

List of Figures

1.0 Introduction

The Hamlet of Colgan is in the Township of Adjala-Tosorontio. The Colgan Drinking Water System (the DWS) currently provides water to a population of 232 people and is primarily residential, but also serves a primary school, church and day nursery. Developments have been planned and are proposing to increase the total population from 232 to 2,794.

The existing DWS supplies flows to the community from a municipal well located south of the community. The well water is pumped into two small reservoirs (total capacity of 90 m^3) then high lift pumps (rated at 3.0 L/s each) pump the water to the distribution (R. V. Anderson and Associates Limited, 2020). The pumphouse houses a two-stage, primary disinfection system consisting of three ultraviolet (UV) reactors, chlorination system utilizing sodium hypochlorite, and an iron sequestering system utilizing sodium silicate.

The existing DWS does not have adequate storage capacity and cannot provide fire protection to the community. An additional at grade reservoir and booster pumping station is being proposed to be fed from an existing transmission main. Currently, the DWS has an approximate water age of two days but the proposed design changes will result in an increased storage volume and associated water age. At very early stages in the development, the water age could be as high as 20–30 days. This bench-scale study was focused on issues that could potentially arise from the expected increase in water age.

2.0 Objectives

The objectives of this bench-scale study were:

1) to conduct a chlorine decay test on the treated water from the DWS;
2) to conduct a simulated distribution system (SDS) test and analyze for THMs and HAAs formation potential; and
3) to monitor general water quality and identify potential issues including aesthetic monitoring for iron that may come out of sequestration.

3.0 Material and Methods

3.1 Water Collection, Sampling and Analysis

Samples of raw water and treated water were collected on-site at the DWS during two visits. For Chlorine Decay Test 1, raw and treated water were analyzed on-site and in intervals throughout the study to determine the concentrations of chlorine (free and total residuals) and silica (from the sodium silicate) remaining over the 20-day detention time along with other water quality parameters (see Table 1 for details). These values were used to assess chlorine dose requirements for Chlorine Decay Test 2.

Chlorine Decay Test 2 was conducted in duplicate (Set 1 and 2) based on the results of Chlorine Decay Test 1. The Centre also conducted a SDS test during Chlorine Decay Test 2. An SDS test involved mimicking the DWS detention times to assess DBPs formation potential. Samples for both THMs and HAAs were collected and sent to an accredited external laboratory. See Table 2 for details on the conducted bench-scale conditions.

Table 1: Methods of Water Quality Analysis

Parameter	Preparation	Method	Range
Turbidity	N/A	USEPA Method 180.1	0 to 1000 NTU
pH	N/A	Hach Method 8156	0 to 14
Apparent colour	N/A	Hach Method 8025	5 to 500 Pt-Co
True colour	Filter sample (0.45 µm)	Hach Method 8025	5 to 500 Pt-Co
UV_{254} absorbance	Filter sample (0.45 µm)	Real Tech UV_{254} Method	0 to 2 abs/cm
Dissolved organic carbon (DOC)	Filter sample (0.45 µm)	Standard Method 5310C UV/persulfate oxidation with conductometric detection	4 ppb to 50 ppm
Total alkalinity	N/A	Hach Method 10244 Titration	10 to 4,000 mg/L as $CaCO_3$
Total iron	N/A	Hach Method 8008	0.02 to 3.00 mg/L Fe
Dissolved iron	Filter sample (0.45 µm)	Hach Method 8008	0.02 to 3.00 mg/L Fe
Free chlorine	N/A	Hach Method 8021	0.02 to 2.00 mg/L Cl_2
Total chlorine	N/A	Hach Method 8021	0.02 to 2.00 mg/L Cl_2
Silica	N/A	Hach Method 8186	0.010 to 1.600 mg/L SiO_2
Sodium	N/A	Hach Direct ISE Method 8322	10 to 1000 mg/L Na
Total manganese	N/A	Hach Method 8149	0.006 to 0.700 mg/L Mn
Dissolved manganese	Filter sample (0.45 µm)	Hach Method 8149	0.006 to 0.700 mg/L Mn
Nitrogen, Ammonia	N/A	Hach Method 8155	0.01 to 0.50 mg/L NH_3-N
Total hardness	N/A	Hach Method 10247 EDTA Titration	100 to 200,000 mg/L $CaCO_3$

Table 2: Bench-Scale Tests Details

Test	Description	Purpose
Chlorine Decay Test 1	Raw water and treated water were collected and left for a detention period of 20 days. Samples were analyzed intermittently throughout this time period to determine decay and addition of chemical as required.	Identified rate of chlorine decay and dosing required to maintain adequate residual over time
Chlorine Decay Test 2	Repetition of first chlorine decay test to confirm and streamline results. Treated water left for a detention period of 20 days. Samples were analyzed intermittently throughout this time period to determine decay and addition of chemical as required.	Assessed chlorine decay, water quality including aesthetic water quality
SDS test	Conducted simultaneously with the Chlorine Decay Test 2. Samples were analyzed intermittently throughout the 20-day detention time.	Assessed if water age affected the formation of DBPs over time

4.0 Results and Discussions

4.1 Chlorine Decay

Figure 1 shows free chlorine levels for Chlorine Decay Tests 1 and 2. The free chlorine level reduced from 2.38 mg/L on Day 0 to 1.73 mg/L on Day 20, which indicates chlorine demand of 0.65 mg/L in Chlorine Decay Test 1. It should be noted that in the SDS method used to conduct chlorine demand and THMs/HAAs tests, samples were kept headspace free in amber coloured glass bottles in the dark at room temperature. The results of chlorine decay of a reservoir may be different as it is open to the atmosphere. There was no need to add chlorine during Chlorine Decay Test 1. Chlorine Decay Test 1 was followed by Chlorine Decay Test 2, which showed an average free chlorine level of 2.32 mg/L (Day 0) dropped to 1.72 mg/L (Day 20) and chlorine demand was 0.60 mg/L. Overall, the free chlorine level dropped by an average of 0.63 mg/L in 20 days.

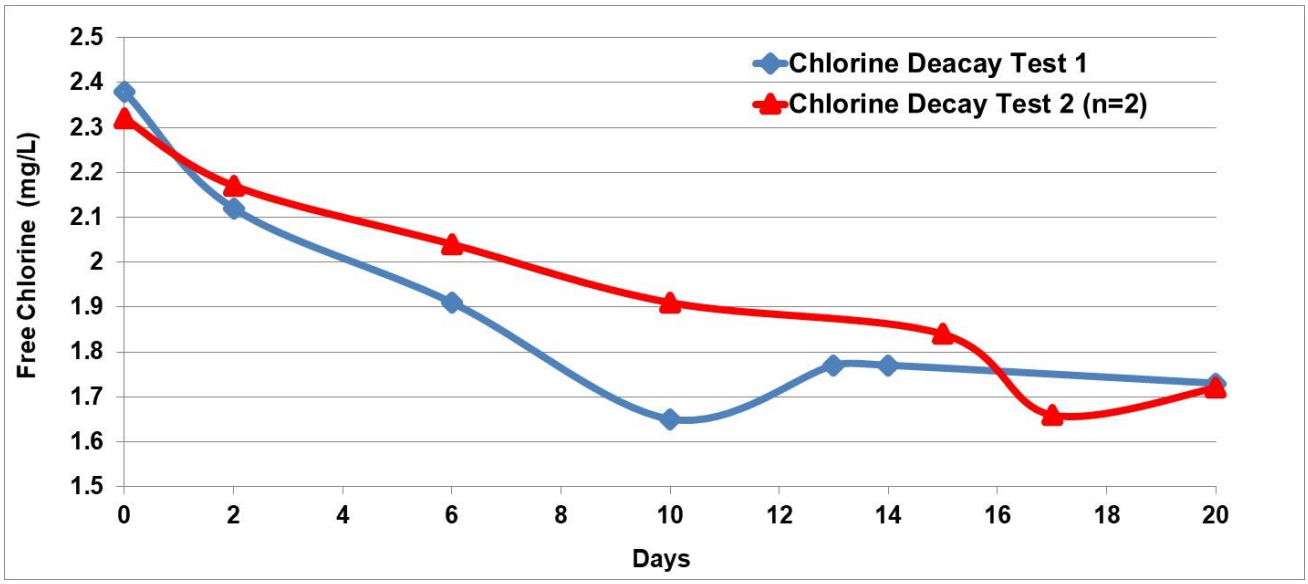

Figure 1. Free Chlorine levels during Chlorine Decay Tests 1 and 2

4.2 Disinfection by-products

4.2.1 THMs

Figure 2 shows THMs levels during Chlorine Decay Test 2. The concentration of THMs was < 0.5 µg/L on Day 0 likely due to the low level of DOC in raw water. THMs levels increased from < 0.5 µg/L on Day 0 to 21.6 µg/L on Day 10. However, the THMs level was reduced to 17.9 µg/L on Day 15. If THMs on Day 15 is considered as an outlier, rate of increase in THMs is higher than that of Day 10–20. Overall, THMs levels increased up to 23.5 µg/L by Day 20 and were much lower than the MAC for THMs of 100 µg/L (MECP, 2006) during the SDS-THMs test.

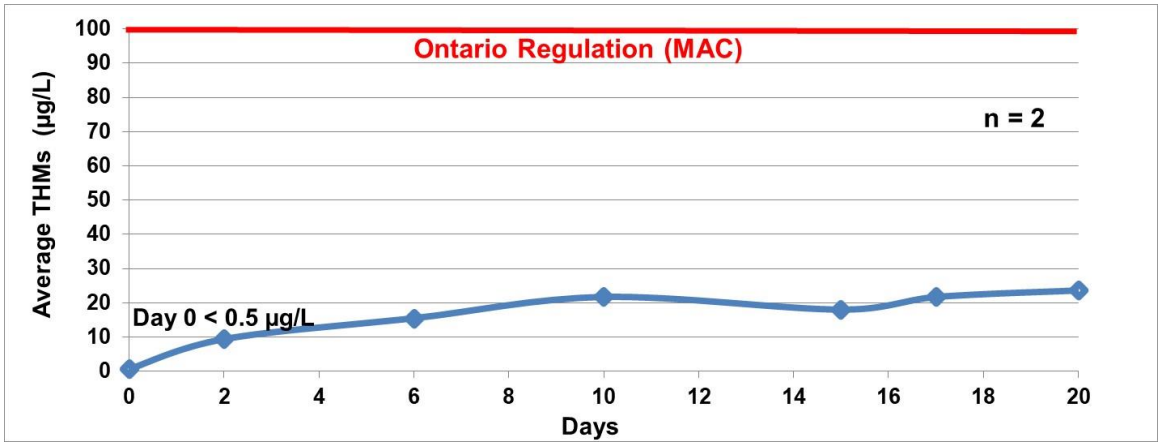

Figure 2. SDS-THMs levels during Chlorine Decay Test 2

4.2.2 HAAs

Table 3 presents HAAs levels during Chlorine Decay Test 2. All results were in single digit or < 5.3 µg/L which is the minimum detection limit (MDL) for this analysis. All HAAs results were significantly lower than the MAC for HAAs of 80 µg/L (MECP, 2020).

Table 3: HAAs levels during Chlorine Decay Test 2

Day	Date	Average HAAs (µg/L), n = 2
Day 0	27-Apr-21	< 5.3
Day 2	29-Apr-21	< 5.3
Day 6	03-May-21	< 5.3
Day 10	07-May-21	< 5.3
Day 15	12-May-21	5.7
Day 17	14-May-21	6.7
Day 20	17-May-21	5.6 & < 5.3

4.3 Aesthetic Water Quality

4.3.1 Iron

The iron sequestration process using sodium silicate keeps iron in its dissolved form. When iron analysis was conducted on-site during Chlorine Decay Test 2 (Day 0), dissolved iron levels were 0.45 mg/L for raw water and 0.41 mg/L for treated water (n=2). However, dissolved iron levels were 0.02 mg/L or less for treated water from Day 2 to Day 20. It appears that iron could have been oxidized during shipping samples to the Centre, despite the presence of sodium silicate. In short, dissolved iron levels could not be monitored properly.

4.3.2 Manganese

Figure 3 presents total and dissolved manganese levels during Chlorine Decay Test 2. Total manganese levels were reduced from 0.04 mg/L for raw water to 0.033 mg/L for chlorinated water and dissolved manganese levels were also reduced from 0.033 mg/L for raw water to 0.029 mg/L after chlorination on Day 0. Total and dissolved manganese were 0.026 and 0.017 mg/L on Day 2, which showed that not all manganese oxidized during transporting samples from the DWS to the Centre, unlike iron. Dissolved manganese levels increased to 0.016 on Day 15 and 17 but ended at 0.007 mg/L on Day 20. Overall, the manganese sequestration process appears to be working, however, both total and dissolved manganese levels were reduced from Day 0 to Day 20.

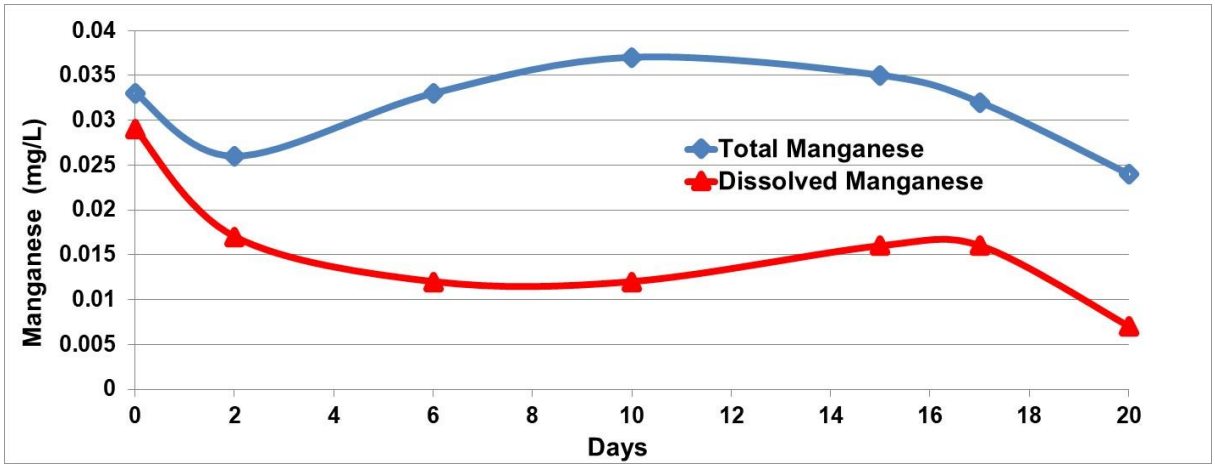

Figure 3. Total and Dissolved Manganese levels during Chlorine Decay Test 2

4.3.3 Colour

The true colour of treated water was < 5 Pt-Co from Day 0 to Day 20 in Chlorine Decay Test 2. The apparent colour of raw and treated water was 22 Pt-Co and < 5 Pt-Co, respectively on Day 0. The apparent colour of treated water was < 5 Pt-Co from Day 2 to Day 6 and then the apparent colour increased to 10 Pt-Co (n=2) on Day 17. Overall, apparent colour levels increased on and after Day 10.

5.0 Limitations

The following limitations were observed during bench-scale testing:

1) Dissolved iron was oxidized during the shipping of samples from the DWS to the Centre. Iron could therefore not be properly assessed in this study.
2) Total and dissolved silica levels were affected by contamination from amber coloured glass sampling bottles. As a result, these results could not be properly assessed.

6.0 Conclusions

The following conclusions can be drawn from this study:

1) The chlorine demand was an average of 0.63 mg/L over 20 days.
2) The highest level of THMs recorded during the SDS tests was 23.5 µg/L on Day 20, which is well below the MAC of 100 µg/L.
3) The highest level of HAAs recorded during the SDS tests was 6.7 µg/L on Day 17, which is well below the MAC of 80 µg/L.
4) Sequestration of manganese appears to be working, however dissolved manganese levels reduced from 0.033 mg/L on Day 0 to 0.007 mg/L on Day 20. Iron came out of solution during transportation and could not accurately be assessed.
5) Apparent colour was consistently above the aesthetic objective (AO) of > 5 Pt-Co in all samples on and after 10 days of detention.

7.0 References

American Water and Wastewater Association, American Public Health Association, Water Environment Federation. (2017). *Standard Methods for the Examination of Water and Wastewater.* Washington, DC: American Public Health Association.

Ontario Clean Water Agency (2019) *Colgan Drinking Water System Annual Report.* Corporation of the Township of Adjala-Tosorontio.

Ontario Clean Water Agency (2019). *Colgan Drinking Water System Summary Report: O. Reg. 170/03 Schedule 22.* Corporation of the Township of Adjala-Tosorontio.

MECP [Ministry of the Environment, Conservation and Parks]. (2006). Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines.

MECP [Ministry of the Environment, Conservation and Parks]. (2020). Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines O. Reg. 373/15, s. 1 (6))

R. V. Anderson and Associates Limited. (2020). *Colgan Water System: Design Basis Review Final Draft.* Toronto.

The Corporation of the Township of Adjala-Tosorontio. (2016). *Drinking Water Works Permit.* Alliston.

WALKERTON CLEAN WATER CENTRE

WCWC.CA

TRAINING · PILOT TESTING ·
RESOURCE LIBRARY · HELPLINE