Meeting Evolving Performance Requirements for Iron and Manganese Reduction in Groundwater

Presentation to NWWC 2023

Nov 15 2023

MAGNOR
Since 1965

Common Pairings

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Common Pairings

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- Intro
- Who is Magnor
- Guidelines
- Technology overview
- Mn < 0.02
- Colloidal Iron

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WHO IS MAGNOR

Who is Magnor

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Who is Magnor

- Canadiens Fans
- Supplier
- From Quebec

But we can still do good things

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Company Profile

- Magnor specializes in the design and manufacturing of water treatment equipment
  - Drinking water
  - Process water
- Founded in 1965
- Canadian based company
  - Greater Montreal Area

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Specialty

- Small systems
  - 15 to 10,000 inhabitants
  - Groundwater
  - Surface Water (Small Flow)

- Contaminant Removal
  - Arsenic
  - Barium
  - Organic carbon
  - Color
  - Hardness
  - Iron
  - Fluoride
  - Manganese
  - Nitrate – Nitrite
  - Dissolved solids
  - Sulfur
  - Turbidity
  - Uranium
  - Others

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GUIDELINES

Why We Need to Treat

- **Iron:**
  - Essential element for human nutrition

    Health Effects:
    - Gastrointestinal distress

    Aesthetic Effects:
    - Discoloured water
    - Off-flavor (bitter or metallic taste)
- **Manganese:**
  - Essential element for human nutrition; found in food
  - More readily absorbed from drinking water with food

    Health Effects:
    - Harmful to neurological development in children
    - Unproven carcinogen

    Aesthetic Effects:
    - Discoloured water
    - Potential for staining

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Guidelines & Treatment Objectives

- **Iron:**

  MAC: N/A

  Aesthetic Objectives:

  - Federal:
    - 0.3 mg/L (also adopted provincially)
    - Newly proposed AO (under consideration): **0.1 mg/L**

- **Manganese:**

  MAC:

  - Federal:
    - 0.12 mg/L (also adopted provincially)

  Aesthetic Objectives:

  - Federal:
    - 0.02 mg/L
    - Recommended treatment goal: 0.015 mg/L
  - Provincial:
    - Varies, but most adopting 0.02 mg/L
    - Ontario is still officially at 0.05 mg/L.
    - BC does not have an AO.

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Fe and Mn Removal Treatment Technologies

OVERVIEW

Treatment Technologies

	PROS	CONS
Pyrolusite	• Meets <0.02 of Mn and <0.3 of Fe even with high concentrations of each	• Higher backwash flows than Greensand, higher water wastage • No anthracite (more risks of fouling
Greensand + (CR)	• Meets <0.02 of MN and <0.3 of Fe even with high concentrations of each • In dept filtration with Anthracite (less fouling risks) • Continuous regeneration of media	• More chemicals to operate ($KMnO_4$ + Cl)

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Treatment Technologies

	PROS	CONS
Greensand + (CO)	• No $KMnO_4$ • Easier to operate • Lower backwash flow than Pyrolusite • In dept filtration with Anthracite	• Cannot guarantee lower than 0.05 of Mn • May need to re-condition media with $KMnO_4$
Biological	• No chemicals	• Operational risks • Not suitable for all water qualities • Longer to startup
Ion Exchange Resins (Softeners)	• One system for Hardness, Fe and Mn	• No hardness in treated water OR bypass (Fe/Mn residuals) • Not efficient with high concentrations • Some regulatory limitations • Risks of fouling

Treatment Technologies

- Others (rarely used in GW for Fe and Mn)
  - Membrane
    - Needs pre-treatment
    - Can potentially treat colloidal iron
  - Multimedia Filter (Sand Anthracite)
    - Will only eliminate particles of Fe and Mn over 7 microns nominal
    - Will not treat ionised Fe / Mn
  - Sequestration
    - Temporary solution for low levels of Fe and Mn

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Problematic #1

ACHIEVING MN <0.02 MG/L

What is the problem?

Problematic #1 – Achieving Mn <0.02 mg/l

- Built-in resistance to treatment
  - Manganese levels fluctuate from source to source
  - Historical compliance
  - Lack of data

- Some traditional technologies cannot address sufficient removal
  - No previous treatment
  - Sequestrants cannot reduce to 0.02 mg/L since overall Mn content is not reduced

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Problematic #1 – Achieving Mn <0.02 mg/l

- Traditional Approaches that will work:
  - Pyrolusite: Can achieve 0.02 mg/L or lower at the cost of higher backwash flows and volume – double than what is required for Greensand
  - Greensand/Greensand Plus: Will effectively reach 0.02 mg/L or less using sodium hypochlorite and potassium permanganate for oxidation and continuous regeneration of the media

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Problematic #1 – Achieving Mn <0.02 mg/l

Resistance to Potassium Permanganate

- Additional chemical
- CAPEX, OPEX
- Additional point of maintenance
- Difficult and even unpleasant to manipulate

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Problematic #1 – Achieving Mn <0.02 mg/l

Options Moving Forward when using Greensand

- 1. Greensand in catalytic mode (CO)
  - Guaranteed to achieve 0.05 mg/L
  - May achieve 0.02 mg/L but performance may degrade over time
  - Has worked on a pilot scale but long term data at full scale is hard to find.

	Raw Water (Avg)	Treated Water Pilot (Avg)	Treated Water (Current Treatment)
Mn (mg/L)	~0.47	0.000 to 0.007	0.000 to **0.036**

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Problematic #1 – Achieving Mn <0.02 mg/l

Options Moving Forward

- 2. Greensand in CO Mode with re-conditioning
  - Will require periodic media re-conditioning through permanganate soaking.
  - Required frequency for re-conditioning cannot be guaranteed

- 3. Greensand in continuous regeneration mode (CR)
  - Can guarantee performance
  - The media manufacturer will only guarantee 0.05 even with permanganate, but Magnor will guarantee 0.02
  - Making provisions for future use if necessary

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Problematic #1 – Achieving Mn <0.02 mg/l

Biological?

Problematic #2

COLLOIDAL IRON REMOVAL

What is the problem?

Problematic #2 – Colloidal Iron

- Particulate iron too small to be filtered
  - Very small
    - Can be smaller than 0.1 microns
  - Causes turbidity
  - Can exceed AO of 0.3 mg/L
  - Could be already oxidized in the water or not

- Could also be organically bound iron hard to oxidize
  - Hypothesis

- Rarely seen in GW
  - But always a risk/uncertainty on Fe removal projects
  - More risk in surface and GUDI water
  - Magnor: 5 cases in 15+ years (4 GW, 1 surface)

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Problematic #2 – Colloidal Iron

- 3 pilot studies + 1 at scale situation
  - Summary of all our findings
  - Details and solutions from our last pilot study

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Problematic #2 – Colloidal Iron

- Summary of what we tried
  - Greensand
    - Particles too small
    - Fe residual too high
    - Doesn't work even with Cl + KMnO4 + Contact Time + pH corrections
  - Cartridge filters
    - Particles are too small
  - Membrane
    - Side pilot by others
    - Effective but costly
    - Other problematics

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Problematic #2 – Colloidal Iron

- Summary of what we tried
  - Ion Exchange
    - Cationic Ion Exchange Resins (Softener)
      - ✓ Works for Ionised Fe
      - ✓ Doesn't work for Oxidized Fe
      - ✓ Removes all hardness
      - ✓ Can foul the resin
    - Anionic Ion Exchange Resins
      - ✓ Performed for 1 day
      - ✓ Only works with organically bound iron
      - ✓ Would require to regenerate too frequently
      - ✓ Long term performance uncertain
      - ✓ Can foul the resin
  - Magnor's Colloidal Iron Removal System (CIRS)
    - In final approval

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Problematic #2 – Colloidal Iron

- At Scale Project (Northern Quebec)
  - A well that had no Fe treatment issue
  - Another well was added
  - Fe AO of 0.3mg/L not met
  - After multiple interventions, we realized it probably was colloidal iron

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Problematic #2 – Colloidal Iron

- Pilot #4 – Most complete approach
  - Greensand CO Mode
  - Greensand CR Mode
  - pH Corrections
  - Contact Time
  - Ion Exchange Resins

- New approach
  - Along with chlorine and KMnO4, add Magnor's CIRS, a new dosing system before the Greensand
  - The objective is to increase the size of particles
  - Promising results

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Problematic #2 – Colloidal Iron

Results

- Greensand CO Mode with/without pH correction (current treatment

	Raw Water (Avg)	Treated Water (Avg)
Fe (mg/L)	0.59	0.26

- Observations
  - ~50% of Iron is removed
  - Lower pH is better, but doesn't solve the problem

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Problematic #2 – Colloidal Iron

Results

- Greensand CR Mode without pH correction
  - With KMnO4 + Chlorine

	Raw Water (Avg)	Treated Water (Avg)
Fe (mg/L)	0.55	0.30

- Observations
  - ~50% of Iron is removed
  - Lower pH is better, but doesn't solve the problem
  - After tests with paper filters, iron is smaller than 0.1 micron

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Problematic #2 – Colloidal Iron

Results

- Greensand CR Mode
  - Without pH correction
  - With KMnO4 + Chlorine
  - Wit 20 min contact time

	Raw Water (Avg)	Treated Water (Avg)
Fe (mg/L)	0.65	0.4

- Observations
  - The contact time doesn't improve the performance

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Results

- Cationic Ion Exchange Resin (before Greensand)

	Raw Water (Avg)	Treated Water (Avg)
Fe (mg/L)	0.55	0.04

- Observations
  - Iron is removed

BUT

  - All hardness is removed, not recommended
  - Risk of resin fouling

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Problematic #2 – Colloidal Iron

Results

- Cationic Ion Exchange Resin (as polisher after Greensand)

	Fe (Raw Water)	Fe (After GS)	Fe (After Resin)
Sample 1 (mg/L)	N/A	0.51	0.40
Sample 2 (mg/L)	N/A	0.14	0.08
Sample 3 (mg/L)	0.64	0.25	0.19
Sample 4 (mg/L)	0.70	0.10	0.09

- Observations
  - Between 10% and 42% of iron is removed after polishing
  - Iron is oxidized and mainly goes through the resin

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Problematic #2 – Colloidal Iron

Results

- Greensand CR Mode + Magnor's **CIRS**
  - With KMnO4 + Chlorine

	Fe (Raw Water)	Fe (After GS)
Sample 1 (mg/L)	0.76	0.03
Sample 3 (mg/L)	0.74	0.02
Sample 5 (mg/L)	0.75	0.00

- Observations
  - Iron is almost entirely removed using Magnor's CIRS
  - Tried different dosing level, optimization is needed
  - None of the problematics of resins

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Next Steps

- Get regulatory approval
- Test at full scale
- Test on other water types
  - Surface water
  - Consistent performance on GW

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Questions?

- Contact Information

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Company Profile

- Magnor specializes in the design and manufacturing of water treatment equipment
  - Drinking water
  - Process water
- Founded in 1965
- Canadian based company
  - Greater Montreal Area

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Company Profile

- Capacity to handle various project sizes
  - <5 usgpm to >3 000 usgpm

- Complete staff to serve your needs
  - Engineers
  - Designers
  - Project Manager
  - Chemists
  - Service technicians
  - Assemblers-fitters

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Specialty

- Small systems
  - 15 to 10,000 inhabitants
  - Groundwater
  - Surface Water (Small Flow)

- Contaminant Removal
  - Arsenic
  - Barium
  - Organic carbon
  - Color
  - Hardness
  - Iron
  - Fluoride
  - Manganese
  - Nitrate – Nitrite
  - Dissolved solids
  - Sulfur
  - Turbidity
  - Uranium
  - Others

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Market Segments

- Drinking water
  - Municipalities
  - Workers' camp
  - Industries not supplied with water by the municipality
  - Tourism and recreational industry

- Process water
  - Using water in their processes
  - Using water in their product (food)
  - pH neutralization

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Our Equipment

- Water Softeners
- Pressure Filters
  - Anthracite
  - Sand
  - Specialized Media
- Activated Carbon Filters
- Greensand Filters
- Ion Exchangers
- Biological filtration

Durable, custom system
- Painted steel tank
- Actuated valve
- Control panel

Fiberglass systems:
- Fiberglass tank
- Integrated control valve

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Our Equipment

- Control & Injection Systems
  - Chlorination
  - pH regulation
  - Coagulants
- Ultraviolet Systems
- Membrane Systems
- Preassembled in Container

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Our Mission

Peace of Mind

for your water treatment projects

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Our Promises

- Long Term Support
- Personalized Service
- Guaranteed Performance

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Technical Service

- Local Service Across Canada
  - Start-up and Commissioning
  - Field testing
  - Preventive Maintenance
  - Repair and Refacing
  - Training

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