Use of Ferrate in Small Drinking Water Treatment Systems

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Objective

- Demonstrate ferrate use including determination of performance, sustainability and economic viability.
- Determine if ferrate treatment can remove or mitigate groups of chemical contaminants and precursors from drinking water systems.
- Illustrate the advantages of ferrate over existing technologies regarding capital, operation and maintenance costs.
- Communicate results to small drinking water systems to increase implementation of ferrate technology if desired.

Working Hypothesis

1. Ferrate is more effective and less detrimental than conventional technologies such as chlorination, chloramination, and permanganate oxidation.
2. Ferrate is comparable in performance to advanced oxidation technologies such as ozonation or chlorine dioxide, which are more costly, more hazardous and/or require expertise to operate.
3. The ability of ferrate to function as an oxidant and coagulant provides an inherent simplicity that may be advantageous to water utilities.

Ferrate Oxidation

Ferrate is a powerful oxidant that decays in water and rapidly oxidizes dissolved iron and manganese.

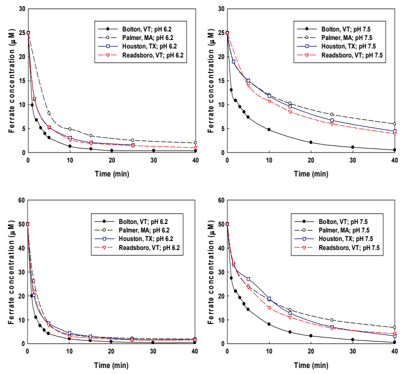


Fig. 1 Ferrate decomposition under varied ferrate dosage and pH conditions.

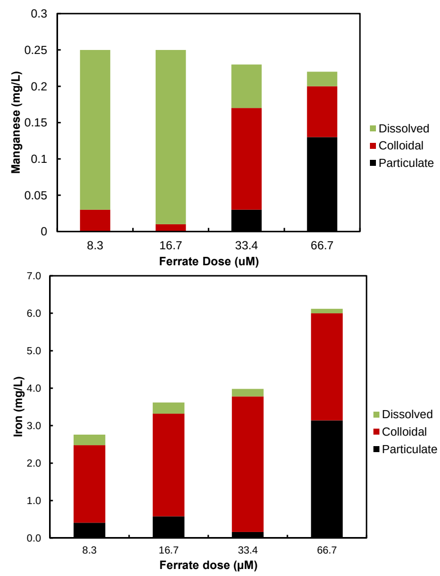


Fig. 2 Manganese and Iron Fractionation After Ferrate Addition –Lantern Hill

Disinfection

- Studies by others (Hu et al, 2008) indicate ferrate can inactivate specific pathogens with modest "CT" values (~36 μM min). Our work shows CT values on this order of magnitude are readily achieved with realistic ferrate dosages and relatively short detention time.
- CT values at pH 6.2 are much smaller than those at pH 7.5, pH had a great effect on CT values.

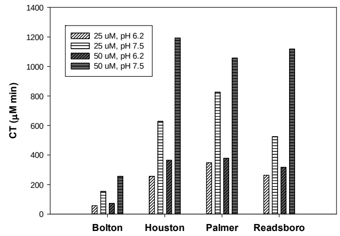


Fig. 3 The CT values of ferrate under varied ferrate dosage and pH conditions.

Disinfection By-Products

- Substantial decrease in THM and THAA but less reduction in DHAA yields was observed.
- Ferrate was effective in reducing DHAN yields, had no significant effect on HKs, but increased the formation of CP.

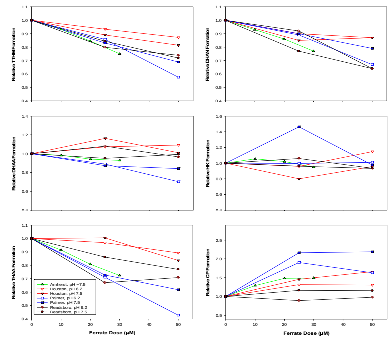
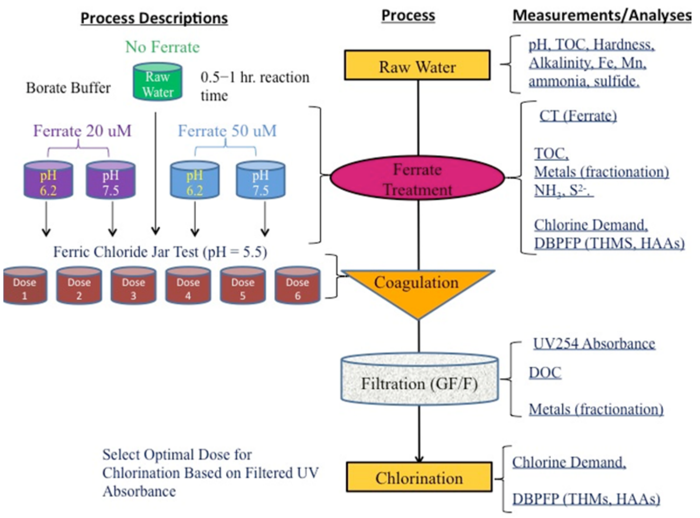


Fig. 4 Effect of ferrate on relative TTHM, DHAA, THAA, DHAN, HK, and CP formation.

Bench-scale Schematic



Conclusions

1. Ferrate successfully oxidizes inorganic contaminants such as iron and manganese. These oxidized metals typically exist in colloidal form, except at higher ferrate dosages, after treatment.
2. Ferrate CT values required for disinfection of viruses are readily achievable in the context of conventional water treatment although dependent on pH. Ferrate treatment destroys DBP precursors to about the same extent that pre-ozonation does.

Future Work

- Bench-scale work will continue to test waters with different properties and chemical contaminants (e.g., pesticides, sulfide, arsenic, PPCPs).
- Pilot-scale work will allow us to collect data on aspects that cannot be readily investigated at the bench scale such as biological removal, sludge production, build-up of filter headloss.