IRON and MANGANESE

FACT SHEET

See related Fact Sheets: Acronyms & Abbreviations; Glossary of Terms; Cost Assumptions; Raw Water Composition; Total Plant Costs; and WaTER Program.

1. CONTAMINANT DATA

A. Chemical Data: Iron (Fe), atomic number: 26, atomic weight: 55.847; and Manganese (Mn), atomic number: 25, atomic weight: 54.938. Both minerals are soluble in their reduced state (+2), and insoluble in their oxidized state (+3).

B. Source in Nature: Both minerals are naturally occurring and present in varying quantities in most soils and rocks, and in surface and groundwaters. The ferrous and manganous (+2) soluble ions are present in water and when exposed to the oxygen in air (oxidized) turn into the ferric and manganic (+3) insoluble ions which will precipitate. While the soluble forms are usually colorless, the ferric precipitate is usually reddish-brown, and the manganic precipitate is usually brownish-black. Additionally, Fe can be added to a distribution system by corroded water pipes, and Mn can occur as a result of landfills or other waste disposal which acidifies groundwater and reduces its oxygen content.

C. SDWA Limits: SMCL for Fe is 0.3 mg/L, and 0.05 mg/L for Mn.

D. Health Effects of Contamination: As secondary drinking water contaminants, neither Fe or Mn pose any health risks, and in small concentrations are essential to human health. Higher concentrations will give water a medicinal or metallic taste; are a nuisance and will cause staining problems in laundry and plumbing fixtures; may precipitate and clog distribution piping; or may cause the development of Fe or Mn bacteria, a harmless bacteria that may give water an offensive taste or color but still is safe to drink.

2. REMOVAL TECHNIQUES

A. USEPA BAT: As secondary drinking water contaminants, BATs are not assigned.

B. Alternative Methods of Treatment: The most common treatment process for removing Fe and Mn is oxidation with $KMnO_4$ followed by greensand filtration. Oxidation of Fe^{+2} and Mn^{+2} ions with $KMnO_4$ occurs after a brief retention time, when an insoluble solid particle is formed which can be removed by the greensand filter. Benefits: proven; reliable. Limitations: chemical dosages and metering required.

Alternative oxidation processes include aeration with oxygen, chlorine, ozone, and hydrogen peroxide. Simple aeration may be the most economical, but may not be as effective.

In-home water softeners may be used when centralized treatment is not available, when the combined Fe and Mn concentrations are below 1 mg/L, and when the Fe and Mn are still in their soluble reduced states (+2).

C. Related WTTP Publications: WTTP Report #8, "Lake Havasu City Water Treatment Research Study." This report pilot tested two processes, including $KMnO_4$ oxidation followed by greensand filtration and nanofiltration to remove Mn^{+2}.

D. Safety and Health Requirements for Treatment Processes: Personnel involved with demineralization treatment processes should be aware of the chemicals being used (MSDS information), the electrical shock hazards, and the hydraulic pressures required to operate the equipment. General industry safety, health, and self protection practices should be followed, including proper use of tools.

3. BAT PROCESS DESCRIPTION AND COST DATA

General Assumptions: Refer to: Raw Water Composition Fact Sheet for ionic concentrations; and Cost Assumptions Fact Sheet for cost index data and process assumptions. All costs are based on *ENR*, PPI, and BLS cost indices for March 2001. General sitework, building, external pumps/piping, pretreatment, or off-site sludge disposal are not included.

Bureau of Reclamation, Technical Service Center
Water Treatment Engineering and Research Group, D-8230
PO Box 25007, Denver CO 80225 (303) 445-2260

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3A. Oxidation with $KMnO_4$ followed by Greensand Filtration:

Process - Oxidation is a chemical process and filtration is a physical process. $KMnO_4$ is added to the raw water which oxidizes the soluble Fe and Mn into insoluble ferric and manganic oxides which will settle and are filterable. $KMnO_4$ (without prechlorination) is usually used according to the following stoichiometry:

0.94 mg/L $KMnO_4$ per mg/L of Fe^{+2} removed and
1.92 mg/L $KMnO_4$ per mg/L of Mn^{+2} removed.

After the oxidation process is complete, the greensand filter removes the insoluble material. Greensand is a green clay material whose active mineral is glauconite, a natural zeolite with ion exchange properties. Greensand is layered loosely to form the media bed. As water passes through the filter, any remaining soluble Fe and Mn are pulled from the solution by the ion exchange properties of the greensand, and the insoluble Fe and Mn are filtered by the greensand media. Periodically, the greensand media is regenerated by continually feeding $KMnO_4$ just before the filter to recharge the glauconite, regenerating the ion exchange properties. Additionally, periodic backwashing of the filter media to remove the Fe and Mn is required.

Pretreatment - Feeding chlorine ahead of the $KMnO_4$ can make the process more economical. $Ca(OH)_2$ addition may be necessary to achieve the desired pH level or to remove CO_2.

Maintenance - Tests should be conducted at least monthly on samples of the water entering the filter to ensure the Fe and Mn are in their insoluble oxidized states (+3) and to verify $KMnO_4$ dosages. Regeneration and backwashing should be done in accordance with the greensand media manufacturer's recommendations. Perform system pressure and flowrate checks to verify backwashing capabilities. Perform routine maintenance checks of valves, pipes, and pumps.

Waste Disposal - Filter regeneration and backwash waters, and spent media require approved disposal.

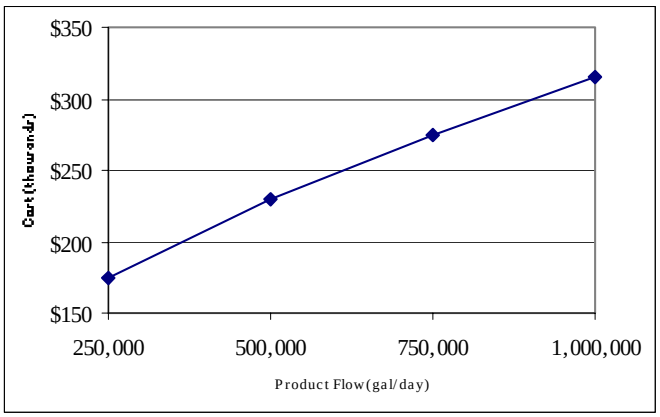
Advantages -

- Low cost.
- Efficient; proven; reliable.

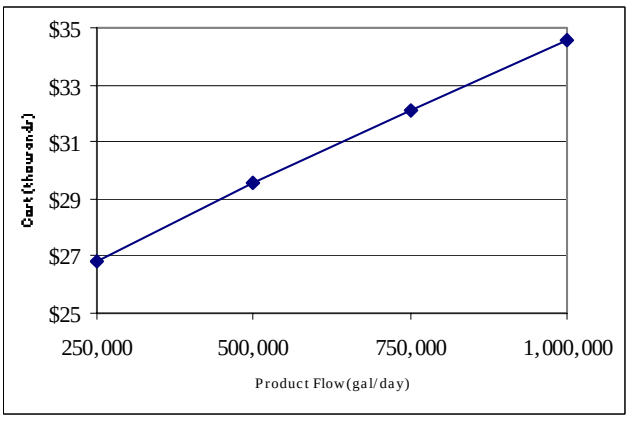
Disadvantages -

- $KMnO_4$ dosage must be exact; bench scale tests are required to determine exact dosage; monitoring of performance to ensure proper dosage.
- Sufficient pressure and flowrate required for backwashing; backwash disposal required.
- Regeneration required; regeneration disposal required.

BAT Equipment Cost*



BAT Annual O&M Cost*



*Refer to Cost Assumptions Fact Sheet. Does not include general sitework, building, external pumps/piping, pretreatment, or off-site sludge disposal.