Aeration oxidation to remove iron and manganese

A. Chemical properties of water

The PH value of water is a critical parameter for the oxidation and precipitation of iron and manganese.

For aeration oxidation of iron, the water should have a pH value of at least 7.2, ideally between 7.5 and 8.0. If manganese is present, a minimum pH value of 9.5 is recommended, below which manganese has a very low rate of aerial oxidation.

If the pH or alkalinity is low, it may be necessary to add an alkaline ingredient, such as sodium hydroxide, to raise the pH.

B. Other factors

Air oxidation of iron and manganese is not immediately complete. For this reason, it is recommended that a contact or retention tank be used to provide sufficient time for oxidation and precipitation to complete. Depending on the actual conditions, the contact time is in the range of 5 to 15 minutes.

C. Reaction equations

Oxidation equation for ferrous ions:

$$4Fe(HCO3)2 + O2 + 2H2O \rightarrow 4Fe(OH)3 + 8CO2$$

Manganese ion oxidation equation:

$$2Mn(HCO3)2 + O2 + 2H2O \rightarrow 2Mn(OH)4 + 4CO2$$

D. Ratios

Iron has an atomic weight of 55.847, and when one oxygen molecule reacts with four iron atoms, the iron atom reacts with four times this value, or 223.39. Oxygen has a molecular weight of 31.999, and the reaction ratio is 31.999/223.39, or 0.1432, meaning that to oxidize 1 mg/L of iron, it would take 0.1432 mg/L of oxygen (as measured by iron).

The atomic weight of manganese is 54.938. When two manganese atoms react with one oxygen molecule, the manganese atom reacts with twice this value, 109.88. The molecular weight of oxygen is 31.999, and the reaction ratio is 31.999/109.88, or 0.2912, which means that to oxidize 1 mg/L manganese, it takes 0.2912 mg/L oxygen (as measured by manganese).

E. Residual oxygen

Sufficient air must be injected into the water to maintain the required residual oxygen for the purpose of:

1. Provide a buffer (flexibility) to cope with fluctuations in iron and manganese levels.
2. Make the water quality more desirable.
3. Create a mixing effect between oxygen and water so that the reaction between iron and manganese and oxygen becomes more rapid and sufficient.

F. Theoretical oxygen demand

theoretical oxygen demand = [Xf·(Fe)] + [Xm·(Mn)] + R

Xf = Iron reaction coefficient
(Fe) = iron concentration
Xm = manganese reaction factor
(Mn) = manganese concentration, mg/L
R = final residual oxygen = (5.0 - initial oxygen) mg/L

Example: (Fe) = 10mg/L, (Mn) = 2.5mg/L, initial oxygen = 0.0mg/L
Oxygen demand = 0.1432 × 10 + 0.2912 × 2.5 + 5.0 - 0.0
= 1.432 + 0.728 + 5
=7.16mg/L Water flow

F. Theoretical air requirements

At 20℃ and 1 atmospheric pressure, the density of air is 1.2047g/L. The oxygen content of air is 20.95%, and the oxygen content per liter of air is (1.2047g/L) × (0.2095) = 0.2524g/L = 252.4mg/L. The oxygen demand of iron is 7.16mg/L, and the flow rate of water is 100L/min.
Example: the oxygen demand of iron is 7.16mg / L, water flow rate of 100L / min.
Theoretical air requirement = (100L/min)(7.16mg/L)/252.4mg/L = 2.84L/min air

G. Actual air requirements

The efficiency of the injector is between 25% and 30%, taking a conservative value of 25%. The actual air requirement is 4 times of the theoretical air requirement, so the actual air requirement is 11.36L/min.
Therefore, the actual air requirement is 11.36 L/min. Depending on the special circumstances, a safety factor of 10% to 20% can be added on top of this.

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