Inorganic Fouling in Air Strippers: Mechanisms and Prevention
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CAUSE

Fouling in air strippers is typically caused by precipitation of inorganic material such as hardness (mainly calcium and magnesium), iron and manganese. The hardness of groundwater varies considerably from place to place. Groundwater is commonly classified in terms of the degree of hardness, as follows: soft (0-75ppm), moderately hard (75-150ppm), hard (150-300ppm) and very hard (greater than 300ppm). The occurrence of iron in groundwater at concentrations of 1-10ppm is common; however, higher concentrations of up to 50ppm have been found in some cases. Manganese is often present with iron in groundwater at concentrations of 0.1-1ppm. Since the concentration of iron is always much higher than the concentration of manganese, fouling in the air strippers is caused more by the precipitation of iron than manganese.

In the air stripping process, carbon dioxide, together with, volatile organic chemicals (VOC's) will be removed from water, causing an increase in pH. As the pH increases, the form of alkalinity will change from bicarbonate to carbonate, and from carbonate to hydroxide. If the water contains an appreciable amount of calcium and magnesium, calcium will precipitate in a carbonate form, and magnesium will precipitate in a hydroxide form. Iron and manganese will precipitate due to the aeration in the forms of iron hydroxide and manganese oxide.

PREVENTION

There are three common approaches for the prevention of inorganic fouling in the prevention of inorganic fouling in the air strippers: 1) enhancing the precipitation before entering an air stripper, 2) sequestering the precipitation by adding an acid to maintain a low pH, and 3) sequestering the precipitation by adding a polyphosphate.

PRECIPITATION AND FILTRATION

Hardness is typically removed from the water by adding lime or caustic soda to adjust the pH, usually above 10.5. It is more difficult to dissolve lime than caustic soda in the water; however, the former will give denser sludge with less volume. The removal of iron and manganese typically involves pH adjustment and oxidation using chlorine, hypochlorite, or permanganate. Permanganate is a more powerful, but more expensive, oxidizing agent than chlorine and hypochlorite. When permanganate is used, it is essential that a media such as greensand (natural ion exchanger, "zeolite") be used to adsorb any excess permanganate after oxidation. Otherwise, excess permanganate will bleed through as a pink color. After the chemical oxidation for either hardness or iron and manganese removal, the sludge needs to be removed from the water through a settling tank and media filters.
ACID SEQUESTERING

One of the advantages of using sequestering agents is that no sludge will be produced due to the inorganic precipitation, and the capital cost can be significantly reduced because there is no need for a setting tank and media filters. However, using an acid as a sequestering agent requires the transportation, storage, and handling of a hazardous material. Also, air strippers, which are constructed of stainless steel or aluminum, may not be compatible with the long-term exposure to an acid.

POLYPHOSPHATE SEQUESTERING

The use of polyphosphates as sequestering agents is more attractive because they are less hazardous, compared to acids. Polyphosphates inhibit the precipitation of hardness by distorting the cube-like shape of calcium carbonate molecules and preventing the molecules from building on each other. Polyphosphates inhibit the iron and manganese precipitation by preventing the close contact between the ions which is necessary for iron and manganese to form their respective oxides. The dosage of polyphosphates, however, should be used with caution where treated water is stored in open reservoirs; because, algae blooms and slime may result. The treated water containing polyphosphates must be discharged in an acceptable body of water.

PREDICTION

Two common predictive indices are used to predict the tendency of water to be corrosive or scale forming, the Langelier’s index and the Ryznar index. Both predict the calcium carbonate stability of water – the result indicates whether it will precipitate, dissolve or be at equilibrium. The calculation is the difference between the actual pH value and the saturation pH (based upon TDS, temperature, hardness, and calcium concentration.

Calculation of LSI should be based upon pH of the air stripper effluent as air stripping increase water pH.

\[ \text{LSI} = \text{pH} - \text{pH}_s \]

**LSI = 0**, water is in equilibrium with CaCO₃
**LSI < 1**, water is undersaturated (possible corrosive) and will dissolve CaCO₃ (no scale)
**LSI > 1**, water is supersaturated and CaCO₃ will precipitate to form scale

For predictive purposes, -0.5 < LSI < +0.5 are not considered significantly scale forming waters.

The Ryznar index was developed from empirical data of corrosion and scale formation rates, indexing relative rates of corrosion or scale formation to a multiplier of the saturation pH

\[ \text{RSI} = 2 (\text{pH}_s - \text{pH}) \]

**6.5 < RSI < 7**, water is considered at equilibrium
**RSI < 8**, water is undersaturated and will dissolve CaCO₃ (no scale)
**RSI < 6**, water is supersaturated and CaCO₃ will precipitate to form scale

For predictive purposes, 5.5 < RSI < 7.5 are not considered scale forming or corrosive water.
GUIDELINES

The general guideline for preventing inorganic fouling in air strippers are as follows:

**Hardness <100ppm and/or dissolved Iron<1ppm**
Air strippers are expected to operate for a long period of time (over a year). No preventative measures are necessary; however, an annual inspection of the interior of the air strippers is recommended. An acid cleaning may be necessary when appreciable inorganic buildup is found.

**Hardness 100-300ppm and/or dissolved Iron 1-5ppm**
Air strippers are expected to operate for at least half a year. No preventative measures are necessary. Periodic cleanings are more economical than the continuous addition of preventative chemicals. It is recommended that the interior of the air strippers be inspected every six months. A dilute acid cleaning is recommended when appreciable inorganic buildup is found. Acid selection should take stripper materials of construction into consideration.

**Hardness >300ppm and/or dissolved Iron >5ppm**
Air strippers are expected to operate for less than half a year and may foul very rapidly. A sequestering agent, preferably polyphosphate, is recommended. An acid should only be used under the following conditions: 1) the use of polyphosphates is not allowed by regulation, 2) the air stripper is constructed of materials compatible with acid and 3) hardness is below 500ppm and/or iron is below 10ppm. When the use of sequestering agent, either polyphosphate or acid, is not practical, the removal of hardness and iron by chemical precipitation and filtering is recommended prior to air stripping.

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