Iron ochre can cause clogging of the subsurface (tile) drainage system. The clogging can occur in the drain perforations, valleys of corrugations, or inside of the drainpipe. Clogging from iron ochre can lead to under-performance or failure of the subsurface drainage system. This bulletin describes the iron ochre issue and its mitigation methods.

1. Iron ochre occurrence

When oxygen in groundwater is depleted after prolonged ponding or saturation, bacteria convert the insoluble ferric iron (Fe$^{3+}$) to soluble ferrous iron (Fe$^{2+}$) in the presence of organic matter. When the soluble iron enters the drain where there is oxygen, bacteria oxidize the soluble iron back to insoluble iron and create ochre. Iron ochre shows up as an orange-brown slimy filamentous deposit in and around the drain (Figure 1). Iron ochre may not occur in the entire drainage system. It can occur in only parts of the drainage system while other areas of the system are without any problem.

2. Iron ochre potential

The highest potential of iron ochre is in fine sand, silty sand, organic soils, organic pans, and mineral soils with mixed organic matter (Ford, 1982). Waterlogged depressional areas with high organic matter are also prone to iron ochre formation. Soils with the least potential of iron ochre are silty clays, clay loam, and clay soils (Stuyt et al., 2005).

3. Iron ochre identification

To identify the potential for iron ochre, measure soluble ferrous iron (Fe$^{2+}$) concentration in the shallow groundwater. With an excavator or auger, dig a hole about 3 to 5 ft deep and take a sample of the groundwater. It is better if the water table is less than 3-ft deep. Use an iron indicator test strip to measure ferrous iron. See Table 1 for risk of iron ochre based on ferrous iron concentration. Analyzing a soil sample for total iron is useless because it includes iron forms that are insoluble and may not cause iron ochre problems. Iron alone does not cause iron ochre; the presence of bacteria generates ochre. Another simple indicator of iron ochre potential is observing orange-brown slime in the drainage ditch.

Figure 1- An extreme case of iron ochre deposits inside of a drain (photo credit: Patrick Ruohy)
Table 1: Iron ochre potential based on an iron indicator test strip (Stuyt et al., 2005).

<table>
<thead>
<tr>
<th>Iron ochre potential</th>
<th>Ferrous iron (Fe²⁺) concentration in test strips (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>&gt;25</td>
</tr>
<tr>
<td>High</td>
<td>10-25</td>
</tr>
<tr>
<td>Moderate</td>
<td>5-10</td>
</tr>
<tr>
<td>Low</td>
<td>1-5</td>
</tr>
<tr>
<td>Negligible</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

An iron indicator test strip is a simple method for identifying the potential for iron ochre.

4. Temporary or permanent issue?

4.1. Temporary issue

When the source of iron is local and there are no extensive quantities of iron in the soil, iron ochre can be a temporary issue. In this case, use mole drains to leach the soluble iron from the soil. For more information about mole drains, see Ghane (2021b). The iron leaching usually peaks over one to three years after installation, followed by a gradual decline of up to about eight years. After the iron leaching has declined, install subsurface drainage (Vlotman et al., 2020).

4.2. Permanent issue

If the iron is moving with groundwater from another source upstream or there are extensive quantities of iron in the soil, ochre can be a permanent issue. Fields having a permanent iron ochre problem should not be subsurface drained without a plan for continuous maintenance and special design considerations.

5. Iron ochre mitigation methods

5.1. Increase soil aeration

Soil aeration prevents the iron from becoming soluble in groundwater. If iron remains insoluble, it cannot move toward the drain. Anything that improves soil aeration minimizes prolonged saturated or ponding conditions. If a plow-pan or compacted layer is preventing soil aeration, break it up with subsoiling or moling to improve water movement to the drains, thereby improving soil aeration (Vlotman et al., 2020). To prevent recurrence of plow-pan or compacted layers, improve soil structure with reduced tillage, cover crops, manure or compost, and diverse rotations to enhance water movement in the soil profile. Those practices minimize waterlogging conditions, thereby improving soil aeration.

5.2. Use drains with large circular or oval perforations

Use drains with large circular or oval perforations (0.2 to 0.5 inches) to extend the time before they get clogged (Bryant and Shaw, 1988). Drains with slotted perforations present the greatest risk of clogging and limit the effectiveness of jet flushing (Stuyt et al., 2005). This is because ochre bacteria bridge the narrower perforation width more quickly.

5.3. Use gravel envelope

Soils with low clay and organic matter may need an envelope because soil particles do not stick together (for example loamy sand, sandy loam, loam, silt loam), thereby causing sediment-clogged drains. In these soils, it is best to use a graded gravel envelope to minimize ochre clogging. To determine if sedimentation is a problem for your drain pipes, see Ghane (2021a).

5.4. Use steeper lateral grade

When designing the drainage system, use steeper lateral grades (within the allowable limit) to promote self-cleaning and low-pressure cleaning (Section 6.1). With a steeper lateral grade, water moves faster and has more force to flush the ochre.

5.5. Run shorter laterals into the ditch

Run laterals into the ditch in the ochre-prone area instead of connecting them to a main pipe. In this case, if one lateral clogs, the entire drainage system does not clog. High-pressure cleaning from the outlet is also easier if laterals flow into the ditch (Section 6.2). Also, install shorter laterals for easier jet flushing form the outlet.

5.6. Use woodchips

Backfilling around the drains with tannin-containing woodchips (such as oak, spruce, pine, cypress, conifer bark) have been shown to adsorb the soluble iron (Fe²⁺) and remove it from water. Also, these tannin-containing woodchips appear to be toxic to ochre-producing bacteria, so they reduce ochre clogging (Stuyt et al., 2005). Besides backfilling woodchips around the drains, you can also fill mesh bags with woodchips and place the bags in access facilities (control structures or...
structures or manholes) along the main pipe. Water in the drainage system is forced to go through the bags for the removal of soluble iron. The woodchip bags will need to be replaced regularly because woodchips adsorb the iron and turn blue over time. This method has been successful in Scotland (Vaughan et al., 1984; Vaughan & Ord, 1994).

5.7. Eliminate the oxygen supply

To reduce ochre formation, eliminate the oxygen supply by keeping the outlet submerged and install deep drains. Keep water in the subsurface drains throughout the year by maintaining a raised weir in a control structure at the system outlet, thereby minimizing the oxygen supply to the drains. This approach is more efficient when deep drains are installed from 4- to 5-ft depth. In the case of a sump pump, the float switch needs to be set higher so that the main and lateral drains are always underwater (Vlotman et al., 2020). Installing deep drains can reduce iron ochre because drains are as far away as possible from the aerated zone, so water at the drain depth has less oxygen to supply to the bacteria.

6. Iron ochre removal methods

6.1. Use low-pressure cleaning

Low-pressure cleaning is useful when the ochre is fresh. To perform low-pressure cleaning, follow these steps. First, use a manhole or a control structure at the system outlet to prevent the drainage system from flowing temporarily. Second, pump water into the drainage system either from the system outlet or from an access facility (manhole or vent) on the uphill end of the pipe. Third, after the pipes are full of water, open the outlet to release water quickly and flush the ochre. This approach is useful with steeper lateral grades, so water moves faster to flush the ochre.

6.2. Use high-pressure cleaning

High-pressure cleaning or jet flushing can remove iron ochre, if it is done early enough, that is typically during the first year after installation. Afterward, clean the drains regularly rather than waiting for the drains to clog. In the absence of regular jet flushing, ochre will harden and become difficult to remove.

High-pressure cleaning can be done from the outlet to loosen the ochre, so it flows out with water. This approach is useful when shorter laterals run into the ditch. If connecting laterals to a main pipe, install access facilities (manhole or vent) on the uphill end of the laterals and use wye connections in the ochre-prone area for better jetting. If access facilities are not available, dig up lateral-main connections for jetting (Bryant & Shaw, 1988). Contact a local sewer, plumbing, or septic tank company for jet flushing (Figure 2).

7. Summary and recommendations

Iron ochre can result in under-performance or failure of the subsurface drainage system. First, identify the risk of iron ochre. Second, perform mitigation methods along with continuous maintenance and special design considerations. One mitigation method may not address the iron ochre issue, but a suite of methods may be needed.

Expert Reviewed

The author expresses gratitude to the reviewers: Dr. Richard A. Cooke (Professor, University of Illinois), Dr. Christopher H. Hay (Senior Research Scientist, Iowa Soybean Association), Dr. Timothy M. Harrigan (Associate Professor, Michigan State University), and William Word (Board Member, Land Improvement Contractors Association, Michigan Chapter).
References


