Private Water Supplies

Iron – Guidance for Local Authorities

Description and Background

Iron is a metallic element, common in most areas. It is a common naturally occurring contaminant of water supplies, but can also be derived from man-made sources such as corrosion of iron pipes or fittings or, rare in private water systems, its use as a water treatment chemical.

Iron has two common oxidation states, +2 (II) and +3 (III) and both of these can be found in water sources. The two states have different properties, so it is important to understand which is present in the supply in order to select appropriate treatment..

Iron (II)
Iron in the second oxidation state is soluble. Solutions containing Iron (II) will often have a greenish tinge, although this is unlikely to be detectable at levels commonly found in drinking water. Iron (II) is readily oxidised to iron (III) on exposure to atmospheric oxygen, however if oxidation is incomplete any soluble iron that is present will pass through filtration processes and not be removed. Water from underground sources such as springs or boreholes will often contain Iron (II) due to the limited oxygen in underground environments.

Iron (III)
Iron (III) is insoluble in water and often forms brown or orange precipitates. It may sometimes be visible as an iridescent film or scum on the surface of water sources high in iron. Water sources with high iron content will often have orange precipitates on surrounding surfaces and vegetation, where iron (II) has emerged from underground and oxidised on contact with air to become insoluble iron (III), often with the assistance of iron bacteria.

Iron is an important parameter in water supplies due to its ability to impair the effectiveness of treatment processes and affect the aesthetic acceptability of the water. High concentrations of iron can impart a metallic taste and significantly discolour the water, rendering it undrinkable. High iron concentrations can be a particular issue where UV treatment is used, as iron can readily coat surfaces in the UV reaction chamber, greatly reducing the transmissivity of the UV radiation.

Iron can combine chemically with organic material present in many upland waters to form complexes. This may make removal more difficult, but oxidation and filtration should still prove effective to some extent. Iron can also be present in colloidal form, where the particles of iron are so small that they remain in suspension indefinitely.

While the iron may impart a colour to the water, this will never settle out and the iron behaves almost as if it is solution, making filtration alone ineffective.

Certain bacteria exist which use iron as a food source and derive energy by oxidising ferric (II) iron to ferrous (III). These are often present where iron rich groundwater emerges into the oxygen rich conditions at the surface. They can also colonise wells and boreholes, which can reduce yields by forming clogging deposits. This situation is something which requires effort to avoid by using good hygiene practices when drilling and maintaining groundwater sources. Once established, colonising iron bacteria are difficult to remove – infected wells can be cleaned physically followed by chemical treatment or pasteurisation. Indicators of the presence of iron bacteria are orange, yellow or red slimy deposits and sometimes a swampy or musty taste and odour to the water.

Health Significance

Iron is abundant in a range of foodstuffs, and drinking water is likely to be only one of a number of ingestion routes. It is an essential element for the human body., although in extreme cases, storage of excess iron in the body can be a problem. WHO do not set a health based guideline value for iron, largely because it is not of health concern at the concentrations in water at which the water could be considered aesthetically acceptable for drinking.

Risk Assessment and Monitoring

The Private Water Supply regulations require monitoring for iron in supplies where it is likely to be present at concentrations in excess of 75% of the 200 μg/l PCV. In practice this is likely to be where iron could naturally occurring, where it could arise from corrosion of ferrous pipes or fittings or where iron salts are used in water treatment as a coagulant. In practice this latter situation will apply to very few private water supplies.

Most upland supplies are likely to contain some iron, so it should probably be included in most initial sampling suites.

Chemical analysis used on water samples will involve the acidification of the sample, reducing all the iron present to oxidation state II, and enabling a value for total iron to be reported. If information is needed on the oxidation state of the iron present, analysis for filtered and total iron should be requested. Analysis of the filtered sample will provide the concentration of soluble iron (II), which can be subtracted from the total iron concentration to determine the amount of insoluble iron (III) present. Care should be taken in sampling to ensure that there is minimal opportunity for additional oxidation to occur en-route to the laboratory.

What if it fails?
When this parameter fails there is unlikely to be any acute health issue for consumers in good health, however if any doubt, health advice should be sought. If there is a coagulation treatment process, this should be the initial focus of any investigation and sampling before and after the process may be beneficial. This scenario is unlikely on private water supplies.

Check the following:

- Operation of any coagulation process
    - Correct coagulant dose used
    - Coagulation is being attempted at correct pH (between 5.5 and 8.5)
- Presence of any corroding iron in the system. This could arise from iron or steel fittings in tanks, intakes, boreholes, treatment processes, or iron water pipes. As metal samples are acidified prior to analysis, any particulate iron arising from these sources will be dissolved and this could give exceptionally high concentrations that are not necessarily representative of those in the water itself. This effect can also mean that the concentrations in iron samples collected from the same location can vary considerably. Progressive sampling through the system for investigatory purposes can sometimes be helpful in identifying a point source of iron such as a length of corroding pipe.
- If the presence of natural iron is suspected, consider additional sampling to better define the extent and variability of failures, especially if there are multiple sources.

Options for resolving at source
These are likely to be limited as iron is ubiquitous in the environment, although if multiple sources are present it may be worth sampling each to see if some contain lower concentrations of dissolved iron than others.

Treatment
Treatment options will depend on the form of the iron that is present. Where coagulation and filtration processes are present, these should be optimised to reduce any residual iron to well below the regulatory standard. Any naturally occurring iron present in the supply should also be removed at this stage.

Where there is no existing treatment, a number of options are possible, following characterisation of the iron present:

- **Aeration and Filtration**
  This is the traditional treatment technology for iron removal and may be used for supplies of all sizes. Aeration is required if all or some of the iron is present in the soluble, iron (II) form. This may well be the case if it is a groundwater. Iron is relatively easy to oxidise and simple aeration can achieve this. Options include bell mouths, cascades, aeration towers and air injection. The choice of aeration process will depend on the circumstances of the supply. Regular maintenance will probably be required to clean iron deposits off any aeration device. A separate aeration stage may be avoidable if iron concentrations are not large (a few milligrams per litre).

  Filtration media can vary depending on the application. Sand can be used, but greensand and other catalytic media may be more effective, especially where some manganese is also present in the water. Most filters will require

backwashing at regular intervals – which will generate waste to be disposed of, and some may need occasional chemical regeneration. Care should be taken in the design of the system to ensure that there is sufficient supply of clean water for backwashing. Backwashing is often automated and takes place at night when demand for water is minimal.

If iron is present in very fine, colloidal state, it may be necessary to dose a coagulant aid such as a polyelectrolyte to attract the particles together into more easily removed clumps.

- **Chemical Oxidation and Filtration**
  Chemical oxidants such as chlorine or potassium permanganate may be used to bring iron out of solution prior to filtration where concentrations are extremely high (>10mg/l) but practical issues with storage, accurate dosing and safe handling of chemicals may make this undesirable for most private water supplies.

- **Ion Exchange**
  Straightforward cationic ion exchange filters, more commonly used to remove water hardness, may also be effective for relatively low concentrations of iron (up to about 1000 μg/l) as positively charged iron ions will also be replaced for sodium ones by the resin. These resins either need to be periodically re-charged using chemicals such as salt, or replaced. The latter is best carried out by a competent contractor. Some companies offer a replacement service whereby the ion exchange filter is exchanged for a new one and the exhausted filter removed and regenerated off-site.

  Ion exchange methods work best where the iron is in the soluble iron (II) form, and care needs to be taken to avoid introducing oxygen prior to the resin otherwise insoluble iron will precipitate out and foul the filter. It is important that pre-filtration is used where there is any risk of fouling the ion exchange resin.

References / Further reading

Dvorak, B; Skipton, S; Woldt, W
NebGuide - Drinking Water: Iron and Manganese
Feb 2014
University of Nebraska

Information for Owners and Users
FAQ sheet provided below

Private Water Supplies

Iron – What You Need to Know - FAQ

What is Iron?

Iron is a metal that is very common in rocks and soils and can dissolve into water in the environment.

Why does it matter?

Iron is not harmful to health at the levels found in water supplies, but it does discolour the water and make it taste unpleasant. At high concentrations it can make the water undrinkable. It is of special significance where ultra-violet light (UV) is used to disinfect water supplies as iron can coat UV lamps and prevent them from disinfecting the water, making it potentially unsafe to drink.

My supply is failing for iron yet it seems alright to me. Why should I do anything?

Iron concentrations in water supplies can vary over time, so it may be worth having a further sample taken to confirm the result. Iron is important because it can coat UV disinfection equipment meaning the supply is no longer being kept safe from microbiological contamination and could make you ill. Even if your supply does not have UV disinfection, the presence of iron can inhibit the performance of other treatment processes such as filtration and chlorine disinfection. There is a legal standard in Scotland of 200 microgrammes per litre for iron in drinking water, which is why local authorities are required to act.

How do I know if iron might be present in my water supply?

Iron quite often shows up as orange / brown discolouration in the water itself or staining of sanitary fittings. Water sources containing high concentrations of iron often show orange / brown deposits on rocks and plants around the source. There can sometimes be an iridescent film on the surface of

the water, almost oily in nature. Many underground water sources contain iron, and this might be in its less visible, soluble, form.

How does iron get into my water supply?

There are a number of ways iron can get into water supplies. In many cases the iron is naturally occurring and comes from rocks or soils that the water passes through. Iron can also come from manmade sources such as old iron pipework or iron tanks or fittings. As these corrode they can put large quantities of iron into the water.

How can I remove iron from my water supply?

If the iron is from a man-made source it may be easier to remove this in the first instance by replacing old iron pipes with plastic and removing any corroding iron fittings. Naturally occurring iron can be removed using simple filtration units, although in some cases aeration may be required before the water is filtered. Your local authority should be able to advise you further.

How much is this likely to cost?

That depends on the size and complexity of the treatment system required, but an iron treatment system can cost in the region of £1000-1500.

How can I find a reputable contractor to install treatment?

A good place to start is the Watersafe website. Watersafe is a UK wide approvals scheme that provides a searchable database of plumbers and contractors with the necessary qualifications and experience to work safely on drinking water systems. The Watersafe scheme can be accessed here: https://www.watersafe.org.uk/ Some local authorities also maintain lists of contractors.

Is there any assistance with the expense of installing treatment?

The Scottish Government provides a grant of £800 per property to make improvements to a private supply. This money may be combined with grants for other properties on the same supply. Grants are administered by your local authority and you should contact the Environmental Health Department of the relevant authority for advice.

Further advice on the safe treatment of private water supplies and the Private Water Supply Grant Scheme may be obtained from the Environmental Health Department of your local authority.