

A Review Paper On Iron And Manganese Influence On Groundwater And Its Removal

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Abstract : Groundwater resources play a vital role in the production of clean and adequate drinking water supply all around the world. Drinking water supplies are based on ground water resources all over the world. At some localities problems with higher concentrations of iron and manganese found in ground water. These higher concentration of these metals result in metallic taste of water, effect color and flavor of food and cause staining of different products like paper, cloths, and plastics. Therefore World Health Organization has approved the treatment of water if concentrations of iron and manganese are higher than 0.3mg/L and 0.1 mg/L. Several techniques have been applied to remove iron and manganese from groundwater.

Iron and manganese are common metallic elements that occurs together naturally especially in deeper wells with little or no oxygen present. Natural sources of iron and manganese may include weathering of iron and manganese bearing minerals like amphibole, iron sulfide and iron rich clay minerals. In areas where groundwater flows through an organic rich soil, iron and manganese will also dissolve in the groundwater. Iron and manganese can also have anthropogenic sources including industrial effluents, landfill leakages and acid mine drainage. Well casing, pump parts, piping and storage tank can also contribute iron and manganese to groundwater. Iron and manganese are undesirable in groundwater. Iron can be present in water in one of three basic forms: dissolved, particulate and colloidal. The predominance of one form over another is dependent on the water's pH.

The present research is to visualize and analyse the effect of iron on the groundwater quality and also to review on the current iron removal methodologies for improving groundwater quality.

IndexTerms – Groundwater quality, Iron, Manganese, Removal.

I. INTRODUCTION

Iron is an essential element for both plant and animal metabolism. Iron is a common constituent in soil and ground water. It is present in water either as soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air, the water turns cloudy due to oxidation of ferrous iron into reddish brown ferric oxide. The concentration of iron in natural water is controlled by both physio-chemical and microbiological factors. It is contributed to ground water mainly from weathering of ferruginous minerals of igneous rocks such as hematite, magnetite and sulphide ores of sedimentary and metamorphic rocks.

Fe concentrations below 0.3 mg/L do not impart a noticeable taste to drinking water. Concentrations of 1-3 mg/L may also be acceptable in case of scarcity, while >3 mg/L iron is likely to be unacceptable to most people. Concentrations of 1-3 mg L⁻¹ may also be acceptable in case of scarcity, while >3 mg L⁻¹ iron is likely to be unacceptable to most people. People often refuse to drink water containing high Fe due to poor taste and discoloration.

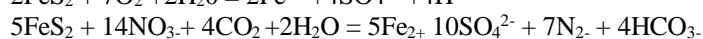
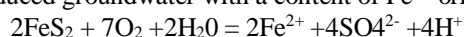
Widespread and elevated groundwater Fe levels have been found in 12 states in India with Rajasthan, Orissa, and Tripura being particularly contaminated. In Rajasthan, 20 out of the total 33 districts have groundwater contaminated with high Fe. High concentrations of Iron in groundwater have been observed in more than 1.1 lakh habitations in the country. High concentration of Iron in ground water has been found in the states of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal & Andaman & Nicobar. In North East India, the amount of iron is relatively high and groundwater in almost all states contains iron above the permissible limit. Higher concentrations of iron were observed in Assam, Arunachal Pradesh, Meghalaya, Mizoram, and Tripura.

Manganese is a naturally occurring and abundant element that is essential in biological systems. The chemical behaviour of manganese is dominated by pH, reduction and oxidation reactions. As a naturally occurring element, manganese is also abundantly available in the environment, and so is found in soils, sediments, surface water and groundwater. Manganese in groundwater comes from rainfall, dissolution of manganese in minerals from surrounding rocks and leaching of manganese in percolating through soils. Greater concentrations of manganese are found in groundwater that are acidic and are in a reduced (anaerobic) condition.

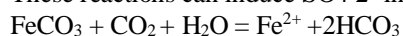
II. ORIGINS OF IRON IN GROUNDWATER

The most common sources of iron and manganese in groundwater are naturally occurring, for example from weathering of iron and manganese bearing minerals and rocks. Industrial effluent, acid-mine drainage, sewage and landfill leachate may also contribute iron and manganese to local groundwater.

Iron can be originated by the weathering of iron minerals such as pyrite. During the Weathering of pyrite in heaps of pit coal, reduced groundwater with a content of Fe⁺² originates



These reactions can induce SO₄²⁻ in pumped raw water. Iron carbonate reacts with CO₂ and get Fe into the solution.



If there is enough CO₂ present and H donors then it will be possible to remobilize the wide spread Fe +3 oxy-hydrates.

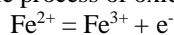


III. CHEMISTRY OF IRON

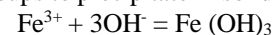
The Iron in water supplies can exist in either of the following states:

- divalent ferrous iron Fe^{+2} (soluble form),
- trivalent ferric iron Fe^{+3} (insoluble form).

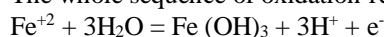
The process of oxidizing divalent ferrous ion (Fe^{+2}) to trivalent ferric ions (Fe^{+3}) can be described by



In circumstances where high concentration of dissolved oxygen occurs, the trivalent ferric ion can further react with hydroxyl groups to precipitate in solid form.



The whole sequence of oxidation-reduction reaction can be written as



The stability of iron ion depends not only on pH but also on activity of electrons which is represented by a redox potential pE. High positive value of pE indicates oxidizing conditions where iron is insoluble and the low values of pE indicates reducing conditions where iron is soluble.

IV. EPA STANDARDS

The Environmental Protection Agency (EPA) has established secondary standards of 0.30 mg/l for iron and 0.05mg/l for manganese(U.S.EPA, 2001). So if concentrations are higher than these standards, then water must be treated before using it for drinking purposes. If water is not treated then there can be different problems for water consumers and also for that municipality that delivers drinking water to consumers.

VI. WHO STANDARDS

When iron and manganese are present in water as soluble form in drinking water supplies, then we will come across many objectionable problems related to their presence. The World Health Organization (WHO) has approved the removal of iron and manganese when concentrations are higher than 0.3 mg/L and 0.1 mg/L respectively (World Health Organization, 1996).

European Union has recommended the levels of 0.2mg/L and 0.05mg/L for iron and manganese respectively (European Union, 1998).

VII. PROBLEMS CAUSED BY IRON CONTAMINATION IN WATER

If water is not treated then there can be different problems for water consumers and also for that municipality that delivers drinking water to consumers. Iron and manganese can cause different types of nuisance problems.

The color and flavor of food and water can be affected by iron and manganese, because they can react with tannins in coffee, tea and alcoholic beverages which result in production of black sludge. Iron can cause reddish- brown staining of laundry, utensils, dishes and glassware. The deposition of iron and manganese in the distribution systems can cause reduction of diameter of pipe and eventually clogging of pipe will take place. Iron and manganese can also cause build up in pipelines, water heaters and pressure tanks. This build up is linked with a decrease in pressure and amount of available water and also increase in cost of water-using appliances. Buildup can be expensive when it results in repairing of water softener or plumbing. The clogging of home softeners can take place and softening efficiency will be reduced by the precipitation of iron and manganese. The excessive concentrations of Manganese will result in metallic taste in water, staining of different products like clothes, paper and plastics.

There is another problem associated with iron and manganese in water is iron and manganese bacteria. These bacteria are not posing any health threat, but they can cause red brown (iron) and black brown (manganese) slime in toilet tanks and can cause clogging of water systems. The growth of iron and bacteria takes place on iron and manganese present in water in either light or dark conditions.

VIII. METHODS OF REMOVAL

8.1 Phosphate Treatment

Phosphate can be added at the source to negotiate the effects of elevated iron concentrations in the distribution system. This is effective when the water contains less than 0.3 ppm of iron or 0.1 ppm of manganese. Phosphate delays the precipitation of oxidized manganese and iron, thereby greatly reducing the layer of scale that forms on the pipe. The effect is called sequestration. The iron or manganese ion is surrounded by a chain of phosphate molecules and is not allowed to precipitate in the water. Pyrophosphate, tri-polyphosphate, and meta-phosphate may be effective as iron and manganese sequestering agents. However, the most effective seems to be sodium phosphate in low concentrations.

The proper dose and type of phosphate should be selected only after bench-scale testing is performed by a qualified technician or consultant. Methods to control iron and manganese in distribution systems include arranging for alternate water sources, adding phosphate to the water to keep iron and manganese in solution, and oxidizing and removing both by filtration.

8.2 Removal by Ion Exchange

Ion exchange may also remove iron and manganese (typically used in home softening). If the water has not been exposed to oxygen, the resins in the softener will remove the iron and manganese ions from the water. If the water contains any dissolved oxygen, the resin can be fouled with iron and manganese deposits. The resin can be cleaned, but the process is expensive and the capacity of this resin is reduced with each cleaning. This method is not recommended for municipal treatment.

8.3 Removal by Iron and Manganese Filtration

Removing iron and manganese from drinking water instead of sequestration is recommended if the water contains over 0.3 ppm of iron or 0.05 ppm of manganese. These elements can be removed during softening with lime, but most commonly iron and manganese is removed by filtration after oxidation (with air, potassium permanganate, or chlorine). Gravity and pressure filters are both used, with pressure filters being the more popular.

8.4 Oxidation with Aeration

Iron is easily oxidized by atmospheric oxygen. Aeration provides the dissolved oxygen needed to convert the iron and manganese from ferrous and manganous (soluble) forms to insoluble oxidized ferric and manganic forms. It takes 0.14 ppm of dissolved oxygen to oxidize 1 ppm of iron, and 0.27 ppm of dissolved oxygen to oxidize 1 ppm of manganese.

8.4 Oxidation with Chlorine

Iron and manganese in water can also be oxidized by chlorine, converting to ferric hydroxide and manganese dioxide. The precipitated material can then be removed by filtration. The higher the amount of chlorine fed, the more rapid the reaction. Most treatment plants use 1 – 2 parts of chlorine to 1 part of iron to achieve oxidation. When using this process on water containing organics such as Total organic carbon or natural organic material, the likelihood of creating disinfection by-products increases.

8.5 Oxidation with Permanganate

Using potassium permanganate to oxidize iron or manganese is fairly common. Potassium permanganate oxidizes iron and manganese into their insoluble states. The dose must be great enough to oxidize all of the manganese, but not too great as this will produce a pink color in the water in the distribution system. Observing water being treated will indicate if adjustments to the chemical feeders are needed. Potassium permanganate is typically more effective at oxidizing manganese than aeration or chlorination.

IX. CONCLUSION

Iron and manganese are common metallic elements bound in the Earth's crust. Water percolating through soil and rock can dissolve minerals containing iron and manganese and hold them in solution that is eventually found in groundwaters and some surface waters that have significant groundwater input. They are mostly present in the soluble reduced divalent form as ferrous (Fe^{2+}) and manganous (Mn^{2+}) ions.

The removal of Fe and Mn comprise two stages: (a) an oxidation process in which the soluble forms of Fe and Mn are oxidized to form insoluble precipitates and, (b) a solid separation process, in which the precipitated material is removed from the water stream. The oxidation process may be a direct chemical reaction, where the electron acceptor may be oxygen or a strong oxidizing agent such as chlorine, chlorine dioxide, ozone or KMnO_4 . This method is particularly helpful when iron is combined with organic matter or when iron/manganese bacteria are present. Chemically precipitated iron and manganese are removed in a rapid gravity or pressure filtration process.

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