

# EXPERIMENTAL INVESTIGATION AND FABRICATION OF REMOVAL OF IRON AND MANGANESE IN GROUNDWATER

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**ABSTRACT:-** 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. Ground water is naturally pure from bacteria at a depth of 30 m or more, however solved metals may occur and if the levels are too high the water is unsuitable to drink. Water containing excessive amounts of iron and manganese can stain clothes, discolor plumbing fixtures, and sometimes add a “rusty” taste and look to the water. Surface water generally does not contain large amounts of iron or manganese, but iron and manganese are found frequently in water systems that use groundwater. The recommended maximum levels by WHO for Iron and Manganese are 2 mg/l and 0.5 mg/l respectively. Several techniques have been applied to remove iron and manganese from groundwater. The aim of this investigation was to analyze the precipitation rates of iron and manganese. Results proved that concentration of oxygen at the water works is high enough to precipitate the level of iron and manganese found in groundwater. The phenomenon of sorption was also included in model to see the adsorption behavior of iron and manganese.

## 1. INTRODUCTION

The presence of Iron and Manganese in ground and surface waters, can cause a number of problems that are related to the health safety of water. Iron and manganese are colourless in the dis-solved form, but in contact with air turn into an insoluble form, and their deposition causes reddish or brown- black colour of the water, metallic taste and unpleasant odour, which impairs the organoleptic properties of water and may promote the growth of certain types of chlorine tolerant micro-organisms. Low concentrations of iron and manganese in water are not considered as a health risk, on the contrary, they are essential, and for this reason they are usually designated as secondary or aesthetic contaminants. However, during prolonged consumption of increased concentrations of manganese in drinking water, it has been found that manganese can damage the respiratory and central nervous system and DNA damage. Increased concentrations of manganese in drinking water can be toxic for the embryo and fetus. Iron and manganese dissolved in water are usually in the form of bicarbonate, sulfate, or

hydroxide, and may also be affiliated to a specific organic substance. The mentioned parameters can occur in the water in dis-solved form (as Fe<sup>2+</sup> and Mn<sup>2+</sup> ions), in the form of particles (as Fe<sup>3+</sup> and Mn<sup>4+</sup> ions) as well as colloids (in the form of small particles that are difficult to be precipitated, and filtered). Regardless of the fact that manganese can be present in water both in dissolved form and in suspended form, only the total manganese is usually determined. The prevalence of certain forms is conditioned by the values of pH, Eh and temperature.

Pollutants such as ammonia, iron and manganese can be removed from the water by chemical or biological means. Physico-chemical oxidation of ammonia is carried out by ion exchange processes, microfiltration, re-verse osmosis, “air stripping” processes or by using a strong oxidizing agent. Oxidation of the ammonia is achieved by the simple aeration. At neutral pH values, the oxidation of Mn<sup>2+</sup> to Mn<sup>4+</sup> represents a slow process, whereas the efficiency of the iron oxidation is much higher and for these reasons, manganese can't be removed by simple aeration and sedimentation. Taking into account that the dissolved manganese oxidizes more slowly than iron, its removal from water is more difficult. Manganese is usually present in water as Mn<sup>2+</sup> ion, and its salts have higher level of solubility in acidic than in alkaline environment. Methods for the removal of manganese are based on the oxidation of the Mn (II) to the insoluble Mn (IV), in the presence of strong oxidants such as KMnO<sub>4</sub>, O<sub>3</sub>, ClO<sup>-</sup>, ClO<sub>2</sub>. Manganese greensand is one of the most common medium in use for removing of iron and manganese, through pressure filtration.

## 2. GROUNDWATER QUALITY

The chemical, physical and bacterial characteristics of groundwater determine its usefulness for various purposes. Chemical analysis of groundwater includes the determination of the concentrations of inorganic constituent. The analysis also includes measurement of pH and specific electrical conductance. Temperature, colour, turbidity, odour and taste are evaluated in a physical analysis (Table 1). Bacteria analysis generally consists of tests to detect the presence of coli form organisms. That pathogenic organisms are rarely found in groundwater, since poor well construction or being associated with bedrock aquifers in which large openings afford direct connection between the surface and groundwater causes most well pathogenic

contamination. That the water quality problem may be associated with and traceable to, any or all of the following: 1. Poor quality source of water, 2. Poor site selection or protection such as apron and lining 3. Construction difficulties and 4. Structural deterioration with age.

## 2.1 SOURCES OF IRON AND MANGANESE

Natural sources of iron and manganese are more common in deeper wells where the water has been in contact with rock for a longer time. In coal mining regions of the state, these metals may also occur from both deep and surface mining activities. Iron and manganese often occur together in groundwater but manganese usually occurs in much lower concentrations than iron.

Both iron and manganese are readily apparent in drinking water supplies. Both impart a strong metallic taste to the water and both cause staining. Water coming from wells and springs with high iron and/or manganese may appear colourless initially but orange-brown (iron) or black (manganese) stains or particles quickly appear as the water is exposed to oxygen (see Water Testing).

Although iron and manganese can occur in wells and springs throughout Pennsylvania, they are most common in northern and western counties. A survey by Penn State found excessive iron concentrations in 17% of the private water supplies sampled in the state..

## 2.2 DRINKING WATER STANDARDS

Iron and manganese are not health concerns in drinking water. Instead, they both have secondary or recommended drinking water standards because they cause aesthetic problems that make the water undesirable to use in the home and a bitter metallic taste that can make the water unpleasant to drink for both humans and farm animals.

Iron can also cause an orange or brown stain in sinks and in the laundry. Manganese often results in a dense black stain or solid. For these reasons, it is recommended that drinking water have no more than 0.3 mg/L (or 0.3 parts per million) of iron and less than 0.05 mg/L of manganese. Remember that private water systems serving individual homes are not subject to state or federal drinking water standards. Thus, these standards only provide guidelines for the proper management of these types of water supplies.

## 2.3 WATER TESTING

The presence of stains, particulates, and metallic taste often make it obvious that iron and manganese are present in a water supply even without water testing. Still, it is a good idea to have your water tested to determine the exact concentration of each of these

metals. The concentration will determine the most practical and economical water treatment options to solve the problem.

In addition to the concentration, it is also important to determine the form of the iron and manganese. If water collected from the well or spring is initially clear but then forms orange-brown or black solid particles over time, the iron and manganese are dissolved in the water. This is known as the "reduced" form of these metals. Dissolved or reduced iron and manganese are most common in groundwater with a pH less than 7.0.

Sometimes, solid particles of iron and manganese will be apparent immediately in water from the well or spring. In this case, the metals are already in the oxidized form. This is more common in higher pH water supplies or where oxygen is readily available to the water, such as a shallow spring.

If you notice orange-brown or black stains with your water or a metallic taste, you should arrange to have your water tested for iron and/or manganese. Iron and manganese are common water pollutants that can be tested by many commercial laboratories in Pennsylvania. Have your water thoroughly tested at a DEP-accredited lab to make an overall treatment plan; see Water Testing for more information.

## 2.4 REMOVING IRON AND MANGANESE FROM WATER

Iron and manganese can be effectively removed from water using a number of treatment processes depending on both the form and concentration of the metals. Since iron and manganese are aesthetic problems that affect all potential uses of the water, they must be removed from all water entering the home using Point-of-Entry (POE) treatment devices.

When multiple treatment processes are applicable to your problem, make sure you shop around and compare treatment units and prices among several reputable dealers that carry a variety of treatment devices. Be sure to understand the maintenance requirements for each unit and get a written warranty for any device you decide to purchase. See Tips for Buying Water Treatment Equipment for more guidance.

## 3. TREATMENT OPTION

### 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 (TOC) or natural organic material (NOM), the likelihood of creating disinfection by-products (DBPs) increases.

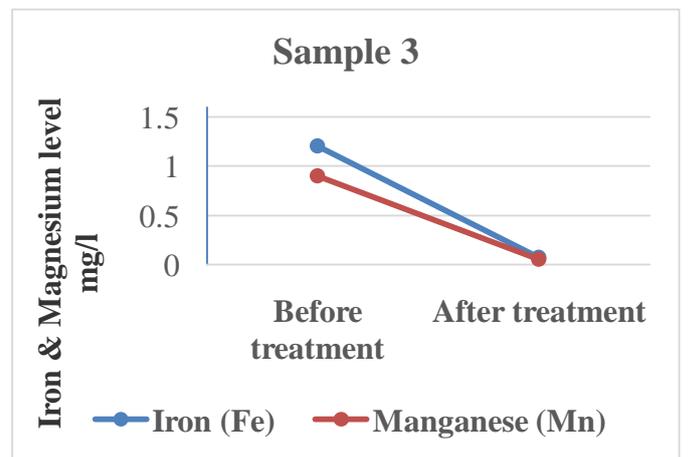
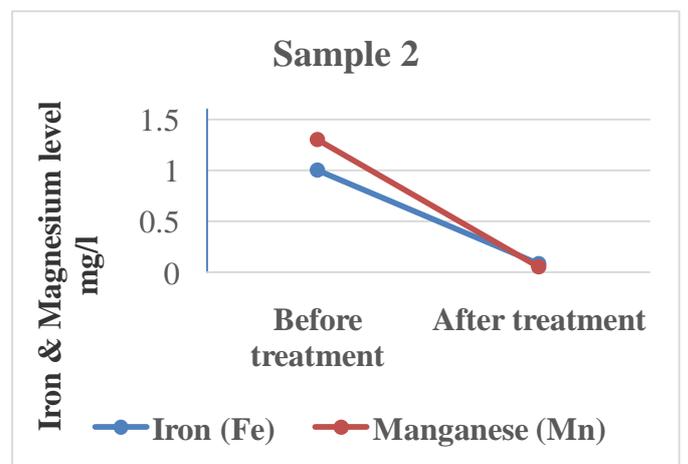
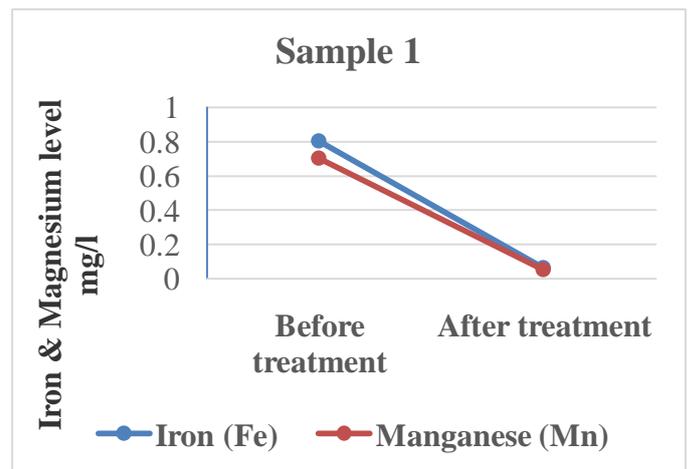
Jar test experiments were carried out with increasing chlorine doses of 10 mg/L. The alum doses applied were 20 mg/L.

The removal of iron and manganese was not significant at lower doses of chlorine (5 mg/L). At 10 mg/L of chlorine dose with a contact period of 5 h at pH 8.0–8.9, there was significant removal of iron and manganese. It is apparent that oxidation of iron and manganese depends on the holdup time, pH and chlorine concentrations. Thus, removal of iron and manganese using chlorine is not practically recommended. When chlorine is used as the oxidizing agent, excess chlorine remains in the treated water. If the particle filter is made of calcite, sand, anthracite or aluminium silicate, a minimum amount of chlorine should be used to avoid the unpleasant taste that results from excess chlorine. An activated carbon filter removes excess chlorine, as well as small quantities of iron/manganese particles. Chlorine oxidizes iron best at a pH of 6.5–7.5. Chlorine should not be used for high levels of manganese, because manganese requires a pH higher than 9.5 for complete oxidation.

### 3.1 TEST RESULTS

#### 3.1.1 Treatment studies with chlorine, Lime and Alum—Iron and Manganese removal

S. No	Oxidant	Coagulants		Contaminates	
	Chlorine (Mg/l)	Alum (Mg/l)	Lime (Mg/l)	Iron (Mg/l)	Manganese (Mg/l)
1	0	0	0	0.8	0.7
	10	20	20	0.06	0.05
2	0	0	0	1.0	1.3
	10	20	20	0.08	0.05
3	0	0	0	1.2	0.9
	10	20	20	0.07	0.05



### 4. CONCLUSIONS

From the above experimental study, the following results were concluded.

Ground water collected from in and around Salem district had pungent odour and yellowish colour in the raw state. Water quality assessment revealed that the colour development and brown/blackish precipitate formation were due to the presence of iron and manganese. Removal of iron and manganese is based on their ease of

oxidation and precipitation. Coagulation is needed to facilitate better setting. Treatability studies were carried out with chlorine as oxidant (10 mg/l). Alum and lime were added for coagulation (20 mg/l).

The oxidation step may be carried out by aeration or more usually by use of a strong oxidant such as chlorine. This treatment process was very helpful for the removal of Iron and Magnesium in the ground water and bring them back to the desired level as per standards.

## REFERENCES

1. WHO, (2008) Guidelines for Drinking-water Quality 3d ed.
2. Joel, A. & Westöm, I (1993) Irrigation costs and possibilities for a sustainable utilization of water – global review Uppsala: Sveriges lantbruksuniversitet
3. Jones, J. A. A. (1997). Global Hydrology – Processes, resources and environmental management. Singapore: Addison Wesley Longman Limited
4. Thureson, L. (1994). Dricksvattenteknik – Groundwater. Stockholm: Svenska vatten och avloppsföreningen, VAV.
5. Ahmed, Awad, Ghaly, Kamel, Talaat (2010) Simultaneous Removal of Iron and Manganese from Ground Water by Combined Photo-Electrochemical Method. Journal of American Science 2010;6(12)
6. Linde, M. Persson, C. Persson, KM. Warfvinge, P. (2005). Mikrobiologisk och kemisk oxidation av mangan i råvatten. Lund: Lund University
7. Connecticut Department of Public Health – Drinking Water Section, Fact Sheet: Manganese in Drinking Water
8. Odell, L. H. (2010) Treatment technologies for groundwater. Denver: American Water Works Association.

## BIOGRAPHIES

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