**Bulletin of Environment, Pharmacology and Life Sciences**
Bull. Env. Pharmacol. Life Sci., Vol 9[7] June 2020 : 166-170

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

**REVIEW ARTICLE** **OPEN ACCESS**

# A Review on Effect Of Corrosion on Underground Water Potability

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**ABSTRACT**

*Corrosion especially in terms of Iron is one of the most critical problems faced by drinking water facilities. Many Parameters affect pipe corrosion, including water quality and composition, flow conditions, biological activity, and corrosion inhibitors. In this review, an endeavour has been made to study corrosion in an attempt to provide the water industry with an updated understanding of factors that influence iron pipe corrosion and its effect on potability of water. In particular, this article focuses on underground water and its potability studies. This review will be useful for researchers across the globes who are working on underground water studies.*
***Keywords:*** *Underground water, corrosion, potability, heavy metals*

Received 18.03.2020 Revised 19.05.2020 Accepted 06.06.2020

## INTRODUCTION

Corrosion is a complex series of reactions between the water and metal surfaces (metal piping) and materials in which the water is stored or transported. The corrosion process is an oxidation/reduction reaction that returns refined or processed metal to their more stable ore state. With respect to the corrosion potential of the drinking water, the primary concerns include the potential presence of toxic metals, such as lead and copper; deterioration and damage to the household plumbing, and aesthetic problems such as: stained laundry, bitter taste, and greenish-blue stains around basins and drains. [1]
The primary health concern is the potential for the presence of elevated levels of lead and copper in the water. The primary source of the lead includes the use of lead pipes, lead lined tanks, and use of 50/50 lead/tin solder. Because of the concern with lead, the EPA banned the use of high lead solders in 1986. The primary source of copper is the leaching of copper from the household piping used to convey the water throughout the home. In some cases, the water is so corrosive that the interior plumbing system needs to be changed and completely replaced with PVC piping, PEX, or other materials. Too bad, they did not test the water and install a neutralizing system before the piping corroded and caused leaks throughout the home. [2]
Corrosion will occur anywhere a galvanic cell or field can be or has established. To establish the field all that is needed is two dissimilar metals that are connected directly or indirectly by an electrolyte, such as water. This is the same chemical reaction that occurs within a battery. Nearly all metals will corrode to some degree. The rate and extent of the corrosion depend on the degree of dissimilarity of the metals and the physical and chemical characteristics of the media, metal, and environment. In water that is soft, corrosion occurs because of the lack of dissolved cations, such as calcium and magnesium in the water. In scale forming water, a precipitate or coating of calcium or magnesium carbonate forms on the inside of the piping. This coating can inhibit the corrosion of the pipe because it acts as a barrier, but it can also cause the pipe to clog. Water with high levels of sodium, chloride, or other ions will increase the conductivity of the water and promote corrosion. [3]
Corrosion can also be accelerated by:
1) Low pH (acidic water) and high pH (alkaline water)- For high alkalinity water - it is possible that a chemical scale may form that would help to protect against corrosion, but if a bacteria becomes

established the scale, such as SRB (sulfur reducing bacteria), you may experience a problem related to Microbiologically Induced Corrosion or MIC;
2) High flow rate within the piping can cause physical corrosion;
3) High water temperature can increase biological rate of growth and chemical corrosion;
4) Oxygen and dissolved CO2 or other gasses can induce corrosion;
5) High dissolved solids, such as salts and sulfates, can induce chemical or bio-chemical corrosion; 6)If the mass ratio (CMSR) of chloride to sulfate is > 0.2, but < 0.5 there is an elevated concern, but if the CMSR is > 0.5 and the alkalinity of the water is less than 50 mg CaCO3/L the concern should be significant;
7) Corrosion related bacteria, high standard plate counts, and electrochemical corrosion can result in pinhole leaks and isolated corrosion and aesthetic water quality problems, and
8) presence of suspended solids, such as sand, sediment, corrosion by-products, and rust can aid in physical corrosion and damage and facilitate chemical and biochemical corrosion.

If it is necessary to flush or run cold water in the morning for a few minutes before drinking because if the water has a bitter taste, the Water is probably corrosive. If blue-green stains are found in basins or some staining along the joints of your copper piping, the Water is probably corrosive. As corrosive water stands or seats in pipes or tanks, it leaches metals from the piping, tanks, well casing, or other metal surfaces that water is in contact. If pink standing are present on the waters edge - this may not be corrosion, but pink bacteria. Pink bacteria is an airborne bacteria.The cost of corrosion can be expensive. Corrosion can impact family's health, aesthetic quality of your water, waste money, and damage the household piping and fixtures. [4]

Corrosive water costs world in a number of ways:
1) Decreases the efficiency of hot water heaters and may cause premature failure to the heater;
2) Corrodes and causes premature failure of household plumbing and plumbing fixtures;
3) Imparts a bitter taste to your water because of elevated levels of metals, which causes you to purchase bottled water;
4) Results in the formation of red water or greenish-blue stains on drains; and
5) Consumption of water with elevated levels of toxic metals, such as lead and copper, have been shown to cause both acute and chronic health problems.

Besides the aesthetic concerns, the corrosion process can result in the presence of toxic metals in your drinking water. These metals include chromium, copper, lead, and zinc. The following are the recommended maximum contaminant levels for regulated public water supplies for the aforementioned metals: chromium (0.05 ppm), copper (1 ppm), lead (0.05 ppm), and zinc (5 ppm). To protect the public, the EPA and PADEP requires public water supplies to be non-corrosive and the "Lead and Copper Rule" has set new action levels for lead and copper of 0.015 ppm and 1.3 ppm, respectively. Because of the toxicity of lead to children, the EPA has established a recommended maximum contaminant level of 0 ppm for lead. If a public water supply is corrosive, the state requires that the water be treated to make the water non-corrosive.

There are no regulations in Pennsylvania or many other states that require private water wells or individual water wells or springs to be tested or treated for corrosivity water. In many states, it is not necessary or even suggested to test private wells for toxic metal, pathogenic organisms, or organic chemicals. [5]

The main drawbacks of the neutralizing filter include:
1) May increase water hardness to more than 120 mg as calcium carbonate or > 7 grains per gallon, i.e., Hard water. The system needs to be properly adjusted.
2) The use of finely ground limestone may result in the reduction of water pressure and some fine media may enter the system.
3) The system requires weekly backwashing. This is typically automated, but it does put a strain on any on lot disposal systems.
4) Neutralizing filters can be used where the raw water pH is 6.0 or greater. A limestone media will raise the pH to only about 6.9 to 7.0. If a higher pH is needed, a magnesia filter media should be used. Get the water tested before installing a system.
5) Many water treatment professionals may install a water softener after the neutralizing filter. In some cases, this can make the water even more corrosive.

The caustic feed system offers more options and is more flexible than the neutralizing filter, but requires additional safety precautions; more expertise to install, setup and operate, and possibly more extensive testing prior to and following installation. The system can treat waters with a lower pH without adding hardness to the water. Typically a sodium-based solution is used as the caustic source, so the sodium

concentration of the water will be increased. Therefore, households those have individuals on a low sodium diet need to make the doctors aware of the treatment system. [6]
The waters with a pH of 4.0 to 6.8 a soda ash (sodium carbonate) is typically used. The soda ash is usually fed into the system at a rate to produce a resultant pH of approximately 7.0. When the raw water pH is less than 4.0, a caustic soda (sodium hydroxide) solution is used. Solutions of sodium hydroxide are extremely aggressive and used only be handled by trained individuals. In general, treatment of groundwater can be accomplished by adding some hardness or alkalinity, or both, and adjusting the pH to slightly increase the scale-forming tendency, thus creating a film or barrier to the corrosion. Installation of dielectric (non-conductive) unions between dissimilar metals such as copper pipe and steel hot water heaters can limit corrosion by breaking the galvanic circuit.[7]
One of the more effective methods of controlling corrosion and leaching of toxic metals into the water is preventive, such as using dielectric couplings, installing CPVC piping and stainless steel equipment. If copper plumbing is used, non-lead solder such as 95/5 tin/antimony solder should be used.It is important to keep in mind that the corrosiveness of the water can be increased by the installation of water softeners, aeration devices, increasing hot water temperatures, chlorinating the water, turbid or fine sediment, and improper matching of metal pipes. Some water treatment equipment such as softeners and aeration systems can aggravate corrosion. Softeners remove the protective calcium and magnesium and introduce highly conductive sodium or potassium into the water and reduce total hardness. Aeration devices for iron, sulfur or odor removal add oxygen, which is extremely corrosive in water. Higher water temperatures and suspended materials accelerate the rate of corrosion by increasing the reaction rates or causing physical damage to the pipes. Chlorine is a strong powerful oxidant which can promote corrosion. [1-10]
All regulated community water systems are required to monitor their levels of lead and copper (Fig. 2), with samples being taken from cold water taps in consumers' homes. Water systems with levels of lead or copper in excess of the action levels will be required to implement corrosion control procedures.

**CHLORIDE : SULPHATE MASS RATIO**
An American Study concluded that Waters with high CSMR were consistently more aggressive in increasing lead leaching (Fig. 1) from solder galvanically connected to copper. Although orthophosphatereduced the extent of lead leaching, the adverse effects ofhigher CSMR were dramatic (e.g., 40 times higher lead)even when phosphates were present. Zinc orthophosphate countered the adverse effects of higher CSMR,whereas zinc alone had little effect. Waters with higher CSMR resulted in increased leadleaching from brass. Dosing of phosphate did not mitigatethe adverse effects of higher CSMR for lead leaching frombrass, whereas zinc orthophosphate or zinc alone did. Regardless of the CSMR, orthophosphate was the mosteffective treatment in the case of solder galvanically connectedto copper pipe, and zinc orthophosphate was most effectivein the case of brass galvanically connected to copper. [3]

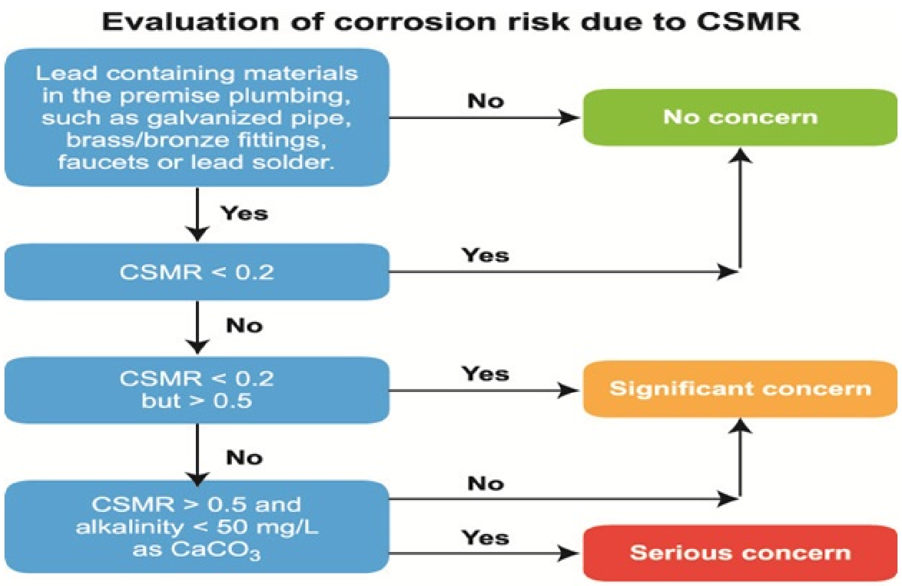


**Fig. 1 Impact of Chloride : Sulphate Mass Ratio (CSMR) on Lead Leaching in Potable Water (Image Source : Water Research Foundation and EPA Study, 2010)**

**Fig. 2 Different Types of Corrosions in Drinking Water Pipes (Source – Google Images)**

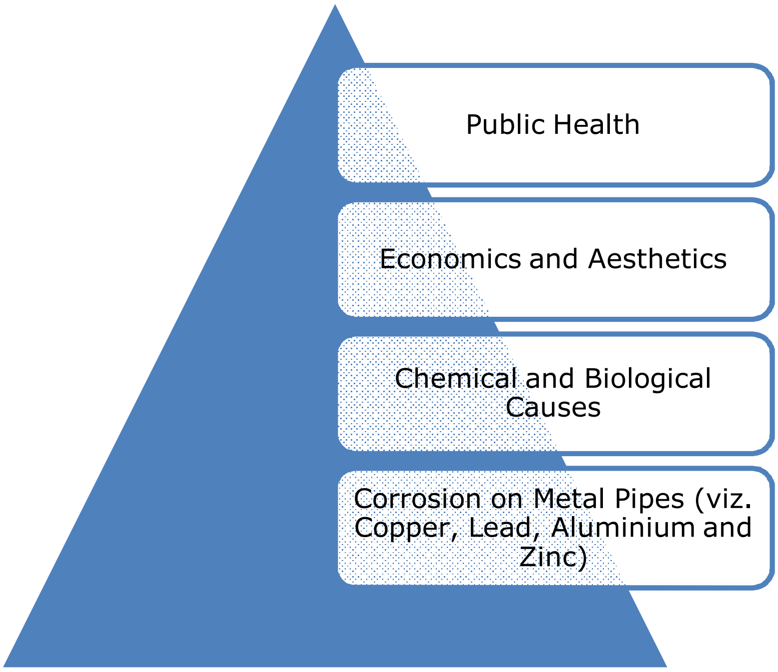


**Fig. 3 Overview of the critical interdisciplinary factors for assessing corrosion in drinking water systems to study Effect of Corrosion on Potabilty of Drinking Water [2]**

## CONCLUSION

There is no strong alternative available for metal pipes to carry drinking water; for such drinking water to be palatable, plentiful, and price-acceptable, the water industry has to consider both the effects of water quality on corrosion and the effects of corrosion on water quality. Corrosion of copper pipe can lead to increased copper levels above the health guidelines; hence, more research is needed to understand the multifaceted causes and effects of copper corrosion. Technological developments are improving copper pipes to minimize scaling and corrosion. Same situations are also applicable for other heavy metals such as Lead, Aluminium and Zinc (Fig. 3). Hence, More Studies are essential to consider the health and aesthetic effects on an equal plane with chemical/biological causes and economics to produce sustainable and economical distribution systems worldwide.

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**CITATION OF THIS ARTICLE**

N Chiwadshetti, R Israni. A Review on Effect Of Corrosion on Underground Water Potability. Bull. Env. Pharmacol. Life Sci., Vol 9[7] June 2020 : 166-170