Asian Journal of Chemistry Vol. 18, No. 1 (2006), 1073–1077

Corrosion and Precipitation Study of Rasht's Water Supply Resources

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Water and wastewater should not corrode the structures, fitting or mechanical equipment with which they come in contact. Aggressive water is drinking water that can cause corrosion. It is a real and growing problem in many parts of the country. Leaks are developing in new homes that are less than 2 years old in some cases. These leaks can cause high water bills and structural damage. Home-owners or municipal water systems that obtain their water from wells are susceptible. The causes and mechanisms that are responsible for the corrosion are not always the same. Water that is slightly acidic is responsible for the corrosion. High levels of dissolved minerals and carbon dioxide can also cause problems. High levels of chloride or sulfate can be serious. In this work the corrosion and precipitation effect of Rasht's water supply resources are studied. The qualitative and quantitative experiments such as pH, dissolved oxygen, CO_2, TDS, temperature, alkalinity, etc. are done during two hydrological years 1997–1999. Water from the stations Otobosrani (O), Seateh (Δ), Helale Ahmar (∅), Razi Hospital (*), Khachekin (◎), Shalco (✳), and Shagaji (□) are not corrosive, but Emamzadeh Hashem (■) is corrosive and treated water (Φ) after treatment of raw water (●) is corrosive in cold water pipes.

Key Words: **Corrosion, Precipitation, Rasht.**

INTRODUCTION

Corrosion is due to the solution of the exposed metal by a physico-chemical action related to the character of the water and the metal. Every metal surface is covered with innumerable small anodes and cathodes and the reaction involving three steps as listed below[1].

1. Metallic loss occurs from the part of the metal pipe called the anodic area (anode). In this case, Fe becomes oxidized to Fe^{2+} ion.
2. As a result of the formation of Fe^{2+}, two electrons are released to flow through the steel to the cathodic area (cathode).
3. Oxygen (O_2) in the water solution moves to the cathode to form hydroxyl ions (OH^-) at the surface of the metal. In the absence of oxygen, hydrogen ion (H^+) participates in the reaction at the cathode instead of oxygen.

The solution of the metal is inversely proportional to the alkalinity, hardness (calcium content), pH value of the water and is directly proportional to the content of dissolved oxygen and carbon dioxide and the temperature and the velocity of the flow of water[2]. There are many other factors, that complicate the problem, some of which are not clearly understood. The corrosiveness of water causes immense economic waste by destruction of pipes, tanks and other vessels[3, 4]. The indirect losses are equally far-reaching. Replacing mains under streets is difficult and costly and the tubercles and incrustations formed inside them by corrosive action decrease the carrying capacity and increase pumping costs. Leaks in buildings involve not only the replacing of the pipe but also repairing damage to walls and furnishings. "Rusty" water stains clothes in laundries and makes unsightly marks on plumbing fixtures. Many natural waters are less corrosive than waters of the same apparent quality after treatment[5, 6]. This is especially the case when softening, which modifies the mineral content of the water, is practised. Therefore, it is important that water and wastewaters should not corrode the structures, fitting or mechanical equipment with which they come in contact. The purpose of this study is to identify the corrosion and precipitation effect of Rasht's water supply resources.

EXPERIMENTAL

Ten permanent stations (Table-1) were sampled bi-weekly for determination of pH and alkalinity, dissolved oxygen, CO_2, TDS and temperature during two hydrological years 1997–1999.

Stations: 1 (Otobosrani), 2 (Seateh), 3 (Helale Ahmar), 4 (Razi Hospital), 5 (Khachekin), 6 (Shalco), 7 (Treated water), 8 (Shagaji), 9 (Emamzadeh Hashem), 10 (Untreated water). No preservatives were added and dissolved oxygen and free carbon dioxide were analyzed immediately. Dissolved oxygen was analyzed (mg/L) by Winkler method[4], the other parameters were analyzed by standard methods[7, 8] and a Seibold GTB pH-meter was used to measure pH (0.05 pH unit).

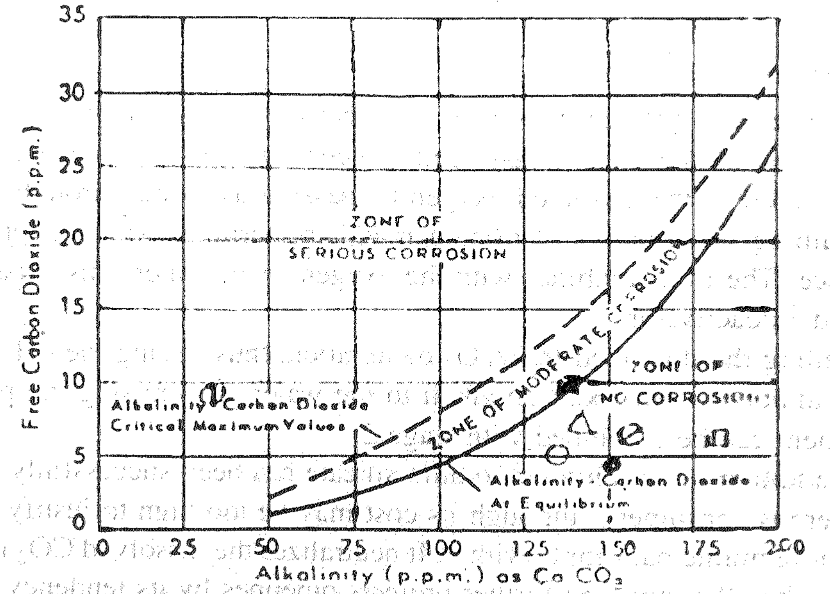
TABLE-1

ANALYSIS OF RASHT'S WATER SUPPLY DURING 1998–1999

Place of Sampling		T (°C)	Ca (mg/L)	Total alkalinity	Dissolved oxygen	CO_2	TDS	pHs	pH	pH-pHs
Otobosrani	○	18	130	125	1	4.8	680	7.6	7.7	0.1
Scatch	Δ	18	70	310	—	15	530	7.5	7.6	0.1
Helale Ahmar	Ø	18	82.2	280	0.65	11	600	7.4	7.7	0.3
Razi Hospital	*	18	77	290	—	5.8	620	7.5	8	0.5
Khachekin	☺	18	70	290	1	5.8	607	7.5	8	0.5
Shalco	※	18	80	300	3	10	600	7.4	7.6	0.2
Treated water	Φ	17	75	42	2.25	7	740	8.3	7.1	-1.2
Shagaji	□	17	90	210	—	14	560	7.5	7.5	0.0
Emamzadeh	■	17	70	177	—	6.8	670	7.75	7.7	–0.05
Untreated water	●	17	70	160	5.5	5	730	7.8	7.8	0

RESULTS AND DISCUSSION

In this work the Langelier formula[7] is used to determine the pH at which the water is in chemical balance and will deposit carbonate scales or dissolve previously formed scales. By comparison of calcium and total alkalinity, TDS and temperature on Langelier's curve, the pH of each water sample is calculated. As shown in Table-1, the pHs for stations 7 and 9 are negative and for other samples are positive. The negative pHs indicate that the water from these stations is corrosive and the positive pHs indicate that it is precipitable. On the other hand, the calcium carbonate film can be deposited when the alkalinity and pH equal or exceed those obtaining at the calcium carbonate equilibrium point (solid curve of Fig. 2); this occurs when pH value is 7.5–9.6 and alkalinity is 150–15 ppm. These conditions are favourable to the precipitation of calcium carbonate from water and its deposition on the pipe. In accordance with the principle outlined above, the pH of water from stations 1, 2, 3, 4, 6, 8, 10 ranged from 7.5 to 8.25 and the total alkalinity ranged from 125 to 310 mg/L. These values are higer than the solubility balance of calcium carbonate and this condition causes the precipitation of calcium carbonate on the internal side of the pipes and protect them from corrosion. It is known that the concentration of CO_2 from 3.0–5.0 ppm is aggressive, and it will dissolve calcium carbonate at alkalinity[3] less than about 80 ppm. As shown in Table-1, the treated water (station 7) contains high concentrations of CO_2 and low alkalinities; these amounts of CO_2 and alkalinities prevent the deposition of calcium carbonate or would dissolve the mineral film



Modified from Cox (1952) p. 186 by permission of the New York St
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Fig. 1. Relationship between alkalinity, carbon dioxide content and the corrosiveness of water (Ref. 5)

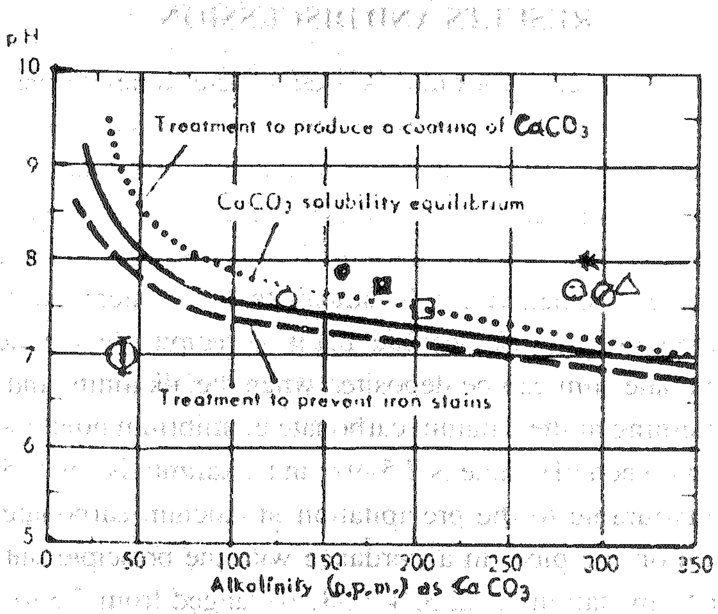

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Fig. 2. Relationship between alkalinity, H^+ concentration, calcium carbonate stability and iron staining[5]

that previously formed and expose the pipe to continued corrosion (Fig. 1). The untreated water (station 10), with 4–5 mg/L CO_2 and 155–160 mg/L alkalinities and positive Langelier index is not corrosive, but this water after treatment such as cholorination and flocculation gets higher CO_2 (station 7) and lower alkalinity and its Langelier index changes to negative. These conditions cause the internal corrosion of the pipe in cold water.

Suggestions

There are several different processes for inhibition of corrosion:

1. Expulsion of the excess dissolved oxygen by means of deaeration and elimination of the dissolved oxygen by passing the water through a vessel containing small pieces of iron such as lathe turnings which offer a large surface. The iron combines with the oxygen in the water; this apparatus is called a deactivator.
2. Expelling the dissolved free CO_2 by aeration, thus raising the pH.
3. The addition of an alkali an alkali to the water, thus raising the pH. This teatment can be combined with stage 2.
4. The addition of an inhibitor sodium silicate has been successfully used by numerous consumers, although its cost may be too high to justify treating an entire municipal supply with it. It neutralizes the dissolved CO_2 in water, raises the alkalinity and further protects pipelines by its tendency to form a protective coating. Sodium hexametaphosphate has also come into use since 1937, and a number of users have reported satisfactory or encouraging results with doses in the range of 1.0 to 10.0 ppm. Sodium chromate is effective as an inhibitor of corrosion in circulating cooling-water systems.

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(*Received*: 18 April 2005; *Accepted*: 12 December 2005) AJC-4534