LEAKAGE OF TRACE METALS BY INTERNAL CORROSION INTO DRINKING WATER DISTRIBUTION SYSTEM

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ABSTRACT

A great portion of the heavy metals present in drinking water distribution systems (DWDS) is due to the raw materials used in manufacturing pipes, valves, and control devices, causing many health and economic problems as well as undesirable changes in water appearance upon corrosion in the system. Monitoring heavy metals in water supply systems is accomplished by the "Lead and Copper Rule" however, a revision of the rule seems necessary for systems in which other metals such as zinc that are used in a much higher percent than copper in manufacturing the metal parts. This study was performed on two water distribution systems in Zarrinshahr and Mobarakeh, Isfahan Province, Iran, in order to determine the concentration levels of heavy metals being introduced into water through corrosion processes. It was revealed that while the concentration levels of lead, cadmium, zinc, iron, and manganese in the raw water supplies for these two towns were less than MCL, but the samples taken along the DWDS show significant increasing concentration levels of all these elements. The results of the study also indicated where the distribution system contains high zinc alloys, "Lead and Copper rule" could be replaced by "Lead and Zinc rule".

Key words: by-products, corrosion, lead-copper rule, micropollutants

Introduction

A major portion of the heavy metal ions present in drinking water distribution systems related to the corrosion of the raw materials used in the manufacture of pipes, valves, and fittings. Corrosion causes micropollutants such as lead, copper, cadmium, zinc, iron, and manganese to dissolve into water. These not only produce an undesirable appearance in water but also cause many health and economic problem [1]. The most important health problem associated with corrosive waters is the presence of lead and cadmium pollutants, which are serious dangers to public health [1, 2]. Water quality changes due to the introduction of copper, iron, and manganese salts and causes objections by consumers due to the stains on clothes and bathroom parts, and also due to offensive odors and tastes [3, 4]. The economic problems include the need for replacing pipes, increased water losses, and introduction of secondary pollutants into the distribution system (1, 4). In order to monitor and control corrosion in DWDS and to prevent the leakage of corrosion by-products into these systems, EPA has recommended the Lead and Copper Rule in the United States of America. Since 1991. The reason for the selection of lead and copper as reference metals in the EPA Rule is the wide application of these two metals in the manufacture of the piping system there [5, 6]. In Iran, however, galvanized pipes are widely used in DWDS and especially in household piping systems. The galvanization is basically a layer of zinc coating. The presence of zinc ions in water, therefore, is much more expected than are other metallic corrosion by-products such as copper.

The objectives of the present study include: 1) determining the concentration of metals introduced into municipal drinking water as a result of corrosion processes; 2) comparison of the present conditions in DWDS with the standards.,nd those recommended by "Lead and Copper Rule"; 3) formulating an executive proposal to replace the present metallic ion measurements with more appropriate ions for measurements not included in the "Lead and Copper Rule".

MATERIALS AND METHODS

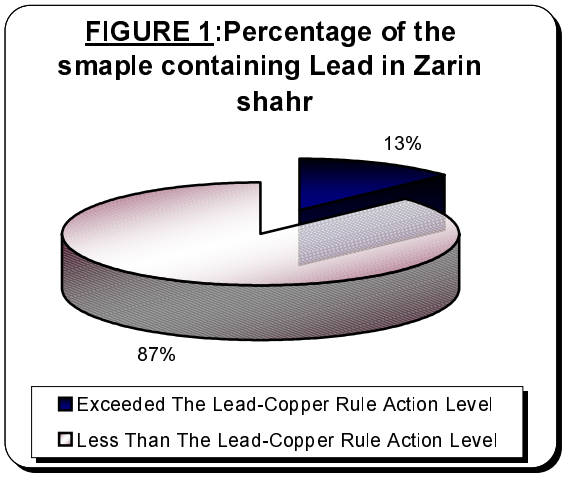
The present study was performed on the DWDS. The study was performed on a pilot scale in two towns in Iran, Zarrinshahr and Mobarakeh in Iran. These two towns have almost identical geographical, demographic, social, economic, and cultural conditions with almost equal areas. The drinking water distributed in Zarrinshahr is supplied by a water treatment plant, which receives its raw water from local abstractions from the Zayandehroud River in the vicinity. The treatment processes include coagulation with alum, settling, filtration, and chlorination. The water had a moderate hardness. The water distributed in Mobarakeh is supplied from groundwater sources through ten wells. The water has a high hardness. The raw water is chlorinated before entering the distribution system. The pipes in both towns were laid over 25 years ago. The materials used in the piping system in both towns are similar. The piping system in houses and buildings are galvanized while the distribution piping systems use asbestos, polyethylene, and in some cases, pig iron pipes. In the present study, the micropollutant concentration levels including lead, copper, cadmium, zinc, iron, and manganese were measured in both raw and tap water in both towns and then compared.

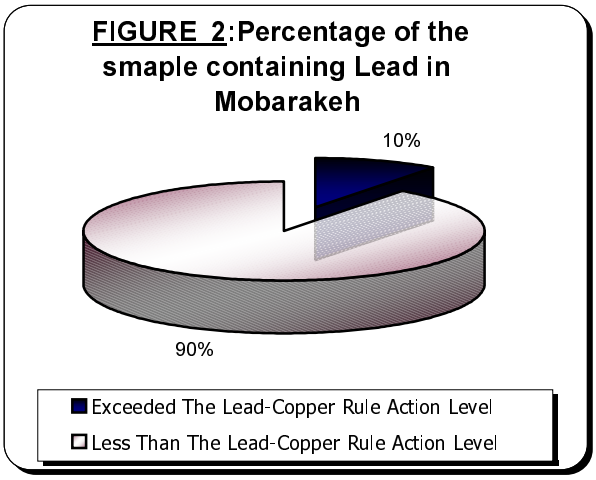
Since the populations covered by the distribution systems are 50,000 people in each town, 30 cold tap water samples were taken with a minimum of 6 hours of retention time in order to comply with the recommendations by the "Lead and Copper Rule" . The number of the samples was going to provide a reliable results based on 95 % confidence. The samples were taken, early morning. To protect the samples, one ml. of conc nitric acid had already been added to the containers. The distribution of sampling points had been selected in such a manner that a full representation of the whole town would be secured. In order to compare the concentrations of corrosion by-products with those in water supplies, the concentrations

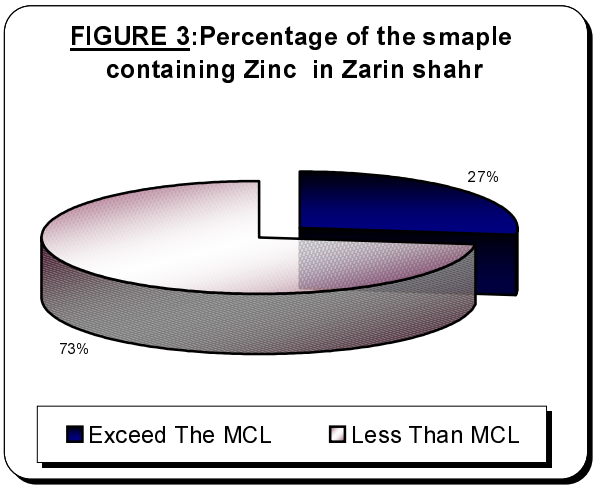
in raw water were also determined. The concentration of water micropollutants including Pb and Cd were determined using flamless atomic absorpthion, and for Zn, Cu, Fe, Mn with the flame atomic absorption method. The findings were evaluated in accordance with recommendations by WHO [8]. The results and data were also compared with WHO standards [8]. The statistical program (SPSS) were used for the data analyses.

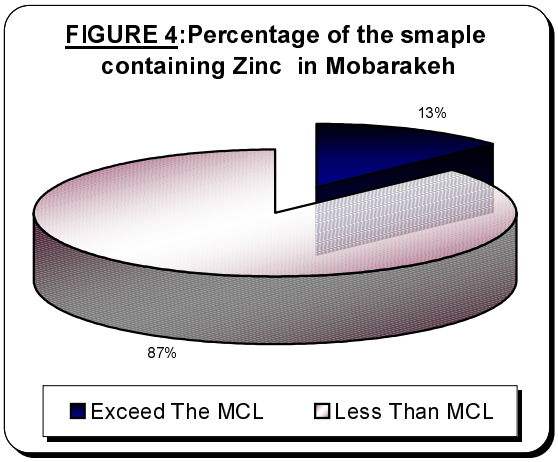
RESULTS

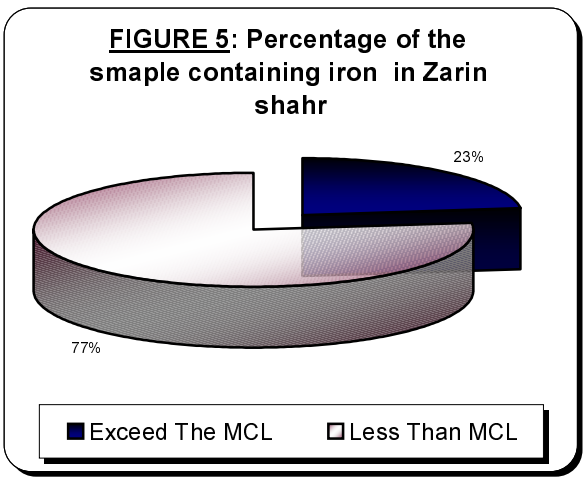
The results for mean, minimum, and maximum concentration levels of lead, copper, cadmium, zinc, iron, and manganese micropollutants in both water supplies and the distribution systems are presented in Tables 1 and 2. Figures 1, 3, and 5 show the percentage of Pb, Zn and Fe in study for Zarrinshahr DWDS, respectively. Figures 2, 4, and 6 show the percentage of the samples for the same micropollutants study in Mobarakeh DWDS. The concentration levels of lead, iron, and zinc in both towns showed variations and in some cases were above the recommended levels. The concentration levels of copper, cadmium, and manganese in both systems were below the MCL (4, 9).











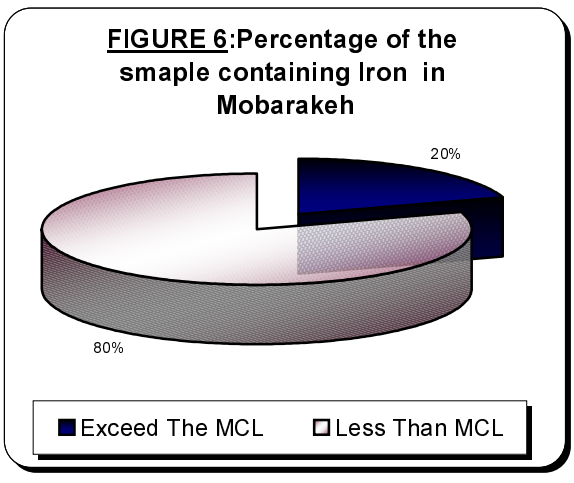


Table 1 Results of micropollutant concentration in the water supply and drinking water distribution system in Zarrinshahr

Micropollutant	unit	Water supply	Distribution system			MCL
			Min.	Max.	Mean	
Lead	µg/lit	1.5	3.1	17.5	5.7	15
Cadmium	µg/lit	0.08	0.09	0.8	0.11	5
Copper	mg/l	0.01	0.01	0.25	0.08	1.3
Zinc	mg/l	0.2	0.93	6	3.4	5
Iron	mg/l	0.08	0.09	0.71	0.23	0.30
Manganese	mg/l	0.02	0.06	0.1	0.07	0.05

Table 2 Results of micropollutant concentration levels in the water supply and drinking water distribution system in Mobarakeh

Micropollutant	unit	Water supply	Distribution system			MCL
			Min.	Max.	Mean	
Lead	µg/lit	0.8	1.4	19.5	7.8	15
Cadmium	µg/lit	0.06	0.4	4.3	0.8	5
Copper	mg/l	0.08	0.1	0.8	0.2	1.3
Zinc	mg/l	0.1	0.3	5.9	3.1	5
Iron	mg/l	0.05	0.07	0.85	0.25	0.30
Manganese	mg/l	0.02	0.02	0.07	0.04	0.05

DISCUSSION

The water supplies in both Zarinshahr and Mobarakeh showed the average lead concentration 1.5 and 0.8 µg/l respectively, while the concentration increased in DWDS up to average 5.7 and 7.8. Also the Cd concentration in water supply in Zarrinshahr and Mobarakeh were 0.08 and 0.06 while the concentration increased up to 0.11 and 0.8 µg/l respectively. It can be cocluded that the leakage of Pb and Cd could taken place via the corrosion of the DWDS.

Lead and cadmium are the two most important by-products of the corrosion process and are considered as the primary water standards. According to the report by the International Cancer Research Organization, lead is classified in the BB2 group ,while EPA suggests cadmium to be classed in the AA2 group [4]. Their presence in DWDS at any concentration indicates the corrosive nature of the distributed water.

As for other corrosion by-products such as copper, zinc, iron, and manganese that are in the secondary standards and their impacts on water appearance are of greater concern [4], the concentrations were less than the MCL (table 1 and 2)

As copper pipes are not common in Iranian DWDS, the only source of copper may be claimed to be more in brass taps and valves used in homes. Their presence in water can indicate the corrosive nature of water which introduces this metal into water after the inner walls of the taps are corroded away . The study showed that zinc in 13% and 27% of the samples in Mobarakeh and Zarrinshahr respectively, exceeded the MCL (figure 3 and 4).

While in Iran the galvanized pipe have a very high percentage of zinc rather than copper, it could be concluded that the "Lead and Cpper rule" could be replaced by "Lead and Zince rule" for coorosion control of the DWDS in any area which have a similar situations.

The results of the study also revealed the leakage of iron into the DWDS which is similar to the other micropollutants . the trend of increasing the concentration were similar for the two towns. The percentage of the excceded the MCL are presented in fig 5 and 6 for the towns studied.

SUMMARY AND CONCLUSION

Comparing the concentration of the micropollutants of water sources for the two towns with the DWDS ,the significant leakage of these metals.observed. The results of the study also showed that the concentration of Pb in 10% and 13% for Zarinshahr and Mobarakeh respectively exceeded the action level based on "Lead and Copper Rule".

"Lead and Copper Rule" could be replaced by "Lead and Zinc Rule"for the DWDS of the cities with a higher percentage of Zinc than copper in the alloys of the pipes, facets, fitting, ect.

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