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Alteration of Iron Level in Drinking Water by Aeration in Gonbad Kavoos (North East of Iran)

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Abstract: Problem statement: In this study, removal of iron was surveyed in well water in Gonbad Kavoos City. **Approach:** Samples were taken before and after aeration. Concentration of iron in each sample was measured by spectrophotometer. **Results:** The results showed that the iron concentration was decreased after aeration (0.55, 0.44, 0.44, 0.46, 0.40 and 0.41 mg L^{-1}) when compared with before aeration of water (0.64, 0.68, 0.65, 0.62, 0.65 and 0.67 mg L^{-1}), respectively. **Conclusion:** It was concluded that using aeration technology can reduce iron concentration conform to internationally approved guidelines for iron.

Key words: Iron level, aeration, drinking water, Gonbad Kavoos

INTRODUCTION

Availability of adequate amount of safe water is the basic need of human being. Access to safe drinking water is the basic human right. Iron is an objectionable constituent of a drinking water. Appreciable amounts of Iron in water impart a bitter characteristic, metallic taste and cause oxidized precipitate. The presence of Iron is a very common water quality problem, particularly in water from deep wells. On a global scale, pathogenic contamination of drinking water poses the most significant health risk to humans and there have been countless numbers of disease outbreaks and poisonings throughout history resulting from exposure to untreated or poorly treated drinking water. However, significant risks to human health may also result from exposure to nonpathogenic, toxic contaminants that are often globally ubiquitous in waters from which drinking water is derived [1]. Water containing even a significant quantity of iron may appear clear when drawn, but will rapidly turn red upon exposure to air. This process is called oxidation and involves the conversion of ferrous (dissolved) iron, which is highly soluble, to ferric (precipitated) iron, which is largely insoluble. In addition Iron stain everything with which it come in contact. In hotels, hospitals, clubs, Institutions, office buildings and homes, Iron-bearing water stain wash basins, toilets, urinals, bath tubs, showers, tiled floors and walls. The standard of 0.3 ppm (0.3 mg L^{-1}) is often recommended and is based on preventing taste and staining problems for humans [2]. Concentration of Iron in excess of 0.2-0.3 mg L^{-1} may cause nuisance even though its presence does not affect the hygienic quality of water (0-0.3 mg L^{-1} Acceptable, 0.3-1.0 mg L^{-1} Satisfactory (however, may cause staining and objectionable taste) and Over 1.0 mg L^{-1} Unsatisfactory). Iron forms complexes of hydroxides and other in-organic complexes in solution with substantial amounts of bi-carbonate, sulphate, Phosphate, Cyanide or Halides. Water is the universal solvent and groundwater usually has some characteristics of the soil and rock where it is found. Because Iron is one of the most abundant minerals in the earth's crust, it is very common in groundwater. When there is too much iron in the water you can see a reddish-brown color, stained laundry and poor tasting coffee. Aeration is an in situ remediation approach that was developed in the late 1980s for treating aquifers contaminated with volatile organic compounds[3]. Different mechanisms (physicochemical and biological) may contribute to iron removal but the dominant one depends on the physical and chemical characteristics of the water and process conditions[4-8]. Among the different techniques, aeration or chemical oxidation followed by rapid sand filtration is most widely used[9,10]. Aeration systems are ways of adding air to water in order replenish its oxygen levels. The more air that is pumped into the water the better the circulation, thus reducing chances of bacteria build up and stratification. This process is most commonly used with non-free flowing bodies of water such as lakes, ponds, farm dugouts, reservoirs. One of the requirements for

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the successful precipitation of iron would be to provide it with sufficient contact time to oxygen so that the minerals can react. Iron removal is technique used to remove excessive iron from water. One of these techniques is aeration of drinking water. This study assesses the possible changes due to the different concentrations of aeration in drinking water (well water No: 16) on iron levels around Gonbad Kavoos city that can be a useful tool for the evaluation of human risk assessment.

MATERIALS AND METHODS

Water samples were collected from the well water number 16 around Gonbad Kavoos city. The city is located in north east of Iran. The speed of water emersion from the well was 20 L sec^{-1}. At the beginning, the plastic container was pooled with the various volumes of water: 1500, 1000, 500, 250, 200 and 100 L. The samples were collected before aeration to determine Iron level. The sample collection procedure was designed to minimize exposure to air. Samples were analyzed after sampling. Then we have pumped the air every 30 min for a time of 300 min (5 h) by aeration pump (total samples were 11 times for each above mentioned volume). When aeration is used as an oxygen injection it is generally done with either an air inductor or an air pump. The air pump method allows more air induced into the water, as a mechanical pump is used to force air into the water. A contact tank is often used. We collected water samples after each 30 min from a tube connected to a sample tap was used to fill glass bottles from the bottom. After the samples were collected for laboratory experiments, the Fe concentration was determined by the phenanthroline colorimetric method[11] and by spectrophotometery, Model DR/2000. PH of the water samples were measured using portable pH meter. The instrument was calibrated with standard pH -7 buffers. PH of water before and after aeration has been measured. Statistical analysis was carried out using student´ t-test for all variables. Data was analyzed by using SPSS-11.5 software. p-value <0.05 was considered significant.

RESULTS AND DISCUSSION

In present study, the level of iron was determined in well water before and after aeration. The Fe concentration measured on well water after aeration (0.55, 0.44, 0.44, 0.46, 0.40 and 0.41 mg L^{-1}) was decreased when compared with before aeration (0.64, 0.68, 0.65, 0.62, 0.65 and 0.67 mg L^{-1}), which was statistically significant (Table 1). The reason for the difference is unknown. However, Fe concentrations greater than 1.5 mg L^{-1} were consistently measured in the laboratory experiments. But the iron concentration remained above WHO guideline value of 0.3 mg L^{-1}. Increasing the aeration time produced a reduction in the Fe level. Aeration caused lowering of Fe concentrations in the well water No 16 was shown in Fig. 1 and 2. As per WHO Guideline, the iron concentration in drinking water should be less than or equal to 0.3 mg L^{-1}. But the iron concentration was more than above value. The probable cause for lesser iron removal may be due to inadequate aeration. In absence of enough oxygen,

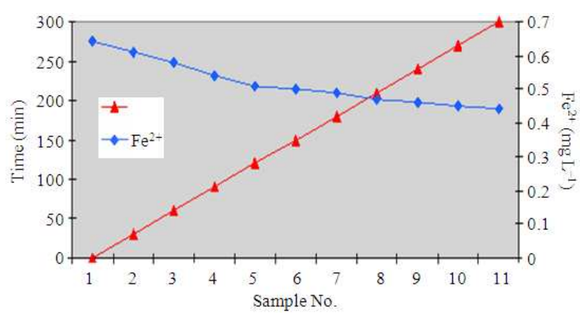

Fig. 1: Variation of iron concentration after different aeration time. (1): Sample number before aeration, (2, 3, 4, 5, 6, 7, 8, 9, 10 and 11): Sample numbers after each 30 min aeration

Table 1: Iron variation according to volume of aeration, Iron levels before aeration, Iron levels after aeration, Oxygen injection and theoretical oxygen requirement

Volume of water sample (L)	Volume of aeration (L min^{-1})	Iron levels before aeration (mg L^{-1})	Iron levels after aeration (mg L^{-1})	Variation of Iron levels (mg L^{-1})	Theoretical oxygen requirement (mg L^{-1})	Oxygen injection (0.14 mg L^{-1})
1500	0.12	0.64	0.55*	0.09	0.012	0.013
1000	0.19	0.68	0.44*	0.24	0.018	0.02
500	0.39	0.65	0.44*	0.21	0.035	0.028
250	0.78	0.62	0.46*	0.17	0.07	0.032
200	0.98	0.65	0.40*	0.25	0.088	0.038
100	1.95	0.67	0.41*	0.26	0.176	0.043

The time of aeration was 300 min for each volume water (1500, 1000, 500, 250, 200 and 100 Liter). *: p<0.05 was significant

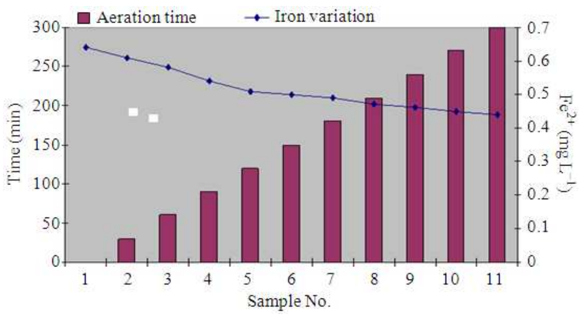

Fig. 2: Variation of iron concentration after different aeration time (1): Sample number before aeration, (2, 3, 4, 5, 6, 7, 8, 9, 10 and 11): Sample numbers after each 30 min aeration

the iron in water remains in ferrous state, which is soluble in water. To remove the iron from water, it must be converted to ferric state. When iron changes to ferric state, it produces gelatinous floc. The flocs are then removed by passing the water through sand layer. It simply indicates that the rate of floc formation is directly proportional to iron removal from water. Oxygen is necessary to convert the ferrous in to ferric. To oxidize the ferrous iron in to ferric, the water must be kept in touch of air or oxygen. pH is one of the very important parameter of water. A large number of chemical reactions are pH dependent. So it is outmost necessary to know the pH of water. The pH of a given water source plays an important role in how quickly ferrous (dissolved) iron converts to a ferric (solid) state. The higher the pH, the faster iron will convert to the ferric state that can then be filtered. However, most experienced water treatment professionals agree that a pH above 7.0 is a must and an 8.0-8.5 pH greatly enhances the chance of a successful application. In this study the pH alteration of water before and after aeration was 8.39-8.51. This can be the reason in our study that decreasing of iron in drinking water after aeration near to WHO guideline.

CONCLUSION

The removal of iron was surveyed before and after aeration of well water in Gonbad Kavoos City was studied. In this study it was showed that iron reduction to levels below internationally approved guidelines is possible using conventional treatment technology. Experimental results showed for the suitable removal of iron. So, the iron concentration was reduced in the samples after aeration of drinking water.

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