

Investigation of Heavy Metal Removal in Different Units of Water Treatment Plant

Afshin Maleki*, Hassan Izanloo¹, Mohammad Ali Zazoli² and Babak Roshani

Department of Environmental Health Engineering
Kurdistan University of Medical Sciences, Sanandaj, Iran

¹Department of Environmental Health Engineering
Qom University of Medical Sciences, Qom, Iran

²School of Public Health and Environmental Health Research Center
Mazandaran University of Medical Sciences, Sari, Iran

✉ maleki43@yahoo.com

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Abstract: In this study, removal efficiency of heavy metals such as iron, manganese, copper and nickel were surveyed in various units of water treatment plant. Samples were taken from influent, before and after sedimentation and after filtration under standard condition. Concentration of heavy metals in each sample was measured by atomic absorption spectrophotometer. The results showed that removal efficiency of iron, manganese, copper and nickel were 71, 60, 79 and 40 percent, respectively. Experimental results currently showed low efficiency for the suitable removal of aluminium. So, the aluminium concentration in all the samples from the influent (2.03 mg l^{-1}) and effluent (2 mg l^{-1}) of the water treatment plant exceeded the EPA drinking water standard ($50 \mu\text{g l}^{-1}$). It is concluded that using conventional treatment technology can reduce metal concentrations except aluminium below internationally approved guidelines.

Key words: Heavy metals, water treatment plant, removal efficiency.

Introduction

Surface water receives various contaminants such as heavy metal salts during their movement. Metallic salts are partially soluble in water, and in high concentration could be harmful. The sources of metals in natural waters are dissolution of natural sediments, and discharging domestic, industrial and agricultural wastewaters (Walter, 1981). Metallic ions in water enter water treatment plants; hence treatment processes should have the ability to remove these matters. Metal ions are released in consequence of salts dissolution. Some of these ions are iron, manganese, copper and nickel. Removal efficiency of these ions is affected by type of process and conditions that are prevailing in treatment process.

Iron concentration in most of surface water resources is high, due to presence of the iron salts in watersheds and constituent of river-bed. Increase of iron in water results in forming of suspended and colloidal particles in combination with organics or minerals. Although presence of iron has no health effects, in high concentrations it affects water quality, causes sediment agglomeration in distribution networks, accelerates iron bacteria growth, and consequently increases corrosion in networks (Walter, 1981). Maximum permissible concentration of iron is 0.3 mg l^{-1} (Amman, 1995). A low amount of this element is harmful. In presence of oxygen or after chlorination it is precipitable as oxide and forms black sludge slimes, and release of this slimes affects taste, odour and quality of water. Manganese accelerates bacterial growths (e.g. manengobacteria) which have taste and odour problems. Standard in

* Corresponding Author

drinking water is 0.05 mg l^{-1} (Amman, 1995). Copper salts are discharged through industrial wastewaters. They are also used to control biological growth in reservoirs and water transport lines. Although copper is an essential micronutrient, in high concentration it causes taste and odour in water and also has physiological effects in human. Presence of copper along with zinc, iron and lead is network corrosion suggestive (Zuan, 1997). Maximum permissible concentration is 1 mg l^{-1} (Amman, 1995). Nickel salts are entered to surface waters through industrial wastewater especially electro-plating industries. Nickel compounds have lower toxicity in comparison with other compounds. Presence of nickel inclined to carbonyl ions has remarkable toxicity. There are some reports on serious damages due to accidental drinking of polluted waters by nickel (WHO, 1991). There are no acceptable standards for nickel (Amman, 1995). Aluminium (Al) is the most abundant metal in the earth's crust (Storey and Masters, 1995; Glynn et al., 1999). Typically, a portion of the alum added to the raw water is not removed during treatment and remains as residual aluminium in treated water (Driscoll and Letterman, 1988; Van Benschoten and Edzwald, 1990). There is considerable concern throughout the world over the levels of aluminium found in drinking water sources (raw water) and treated drinking water (Srinivasan et al., 1999). A high (3.6 to $6 \mu\text{g l}^{-1}$) concentration of aluminium may precipitate as aluminium hydroxide giving rise to consumer complaints (Srinivasan et al., 1999; Lopez et al., 2002). Aluminium is also a suspected causative agent of neurological disorders such as Alzheimer's disease and presenile dementia (Srinivasan et al., 1999; Lopez et al., 2002; Gardner and Gunn, 1991; Jekel, 1991). Treatment process should decrease the concentration of the metals below standards.

The purpose of this study is to determine metals removal efficiency (iron, manganese, copper, nickel and aluminium) in various units in Isfahan Water Treatment Plant.

Materials and methods

Samples were taken from various parts of water treatment process, including intake, rapid mix, before and after filters, and effluent. Samples were taken using Grab method, with plastic container according to Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, WPCF, 1995). Samples were analyzed less than 2 h after sampling. Sampling period was one month, and preservation was accomplished by adding nitric acid down to pH 2.

Samples were analyzed using Perkin Elmer Atomic Absorption, Model 2380. The Aluminium concentrations were determined by Spectrophotometry Eriochrom Cianin R method (APHA, AWWA, WPCF, 1995).

Results and Discussion

Water treatment process in Isfahan Water Treatment Plant is by conventional methods. This means that treatment process during coagulation, flocculation, sedimentation, filtration and chlorination removes particular and colloidal matters (whether organic or mineral). Because metallic ions enter treatment plant in soluble form, treatment process can not remove them completely. Conventional water treatment processes can only reduce relatively metallic salts using trapped salts in flocs during flocculation and then during sedimentation and filtration process (Montgomery, 1985). Also chlorination can oxidize some metallic salts; and hence can reduce relatively some of the oxidized metal solutions. Figures 1 to 5 show iron, manganese, copper, nickel and aluminium variations in water treatment processes in treatment plant.

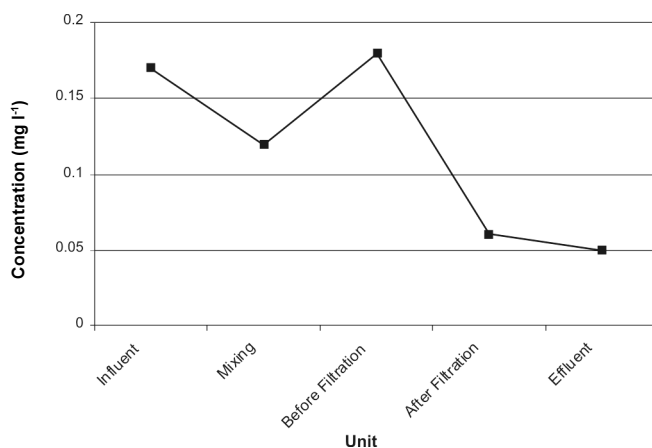


Figure 1: Iron variation during water treatment process.

Results showed that concentrations of these pollutants in effluent are lower than influent. Removal efficiency for iron, manganese, copper and nickel is 71, 60, 79 and 40 percent respectively. Variation in manganese and nickel concentration was descending. Most of the copper removal was in coagulation processes (73 percent), while after that removal was only five percent. Floc forming was because of application of coagulants containing iron, and iron oxidizing due to aeration before mixing and pre-chlorination reduced iron content in filtered water.

The mean aluminium concentration in the samples collected from influent of the water treatment plant was

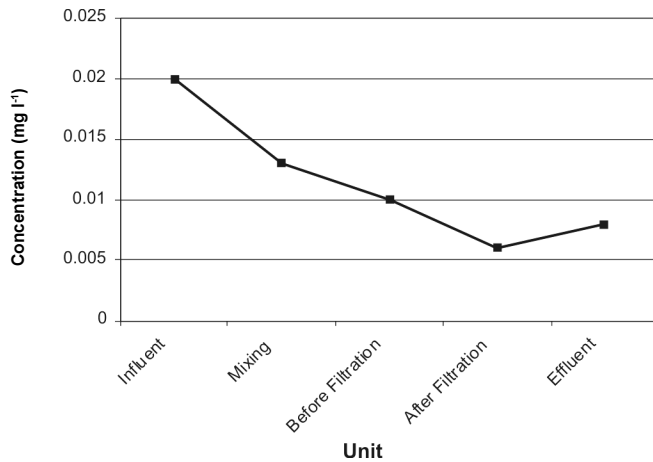


Figure 2: Manganese variation during water treatment process.

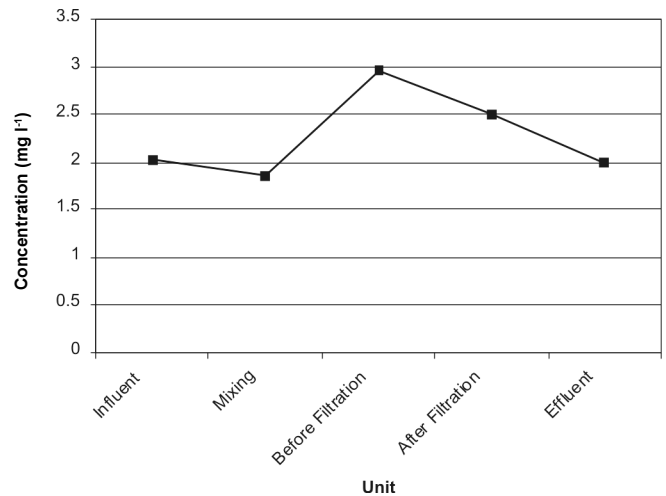


Figure 5: Aluminum variation during water treatment process.

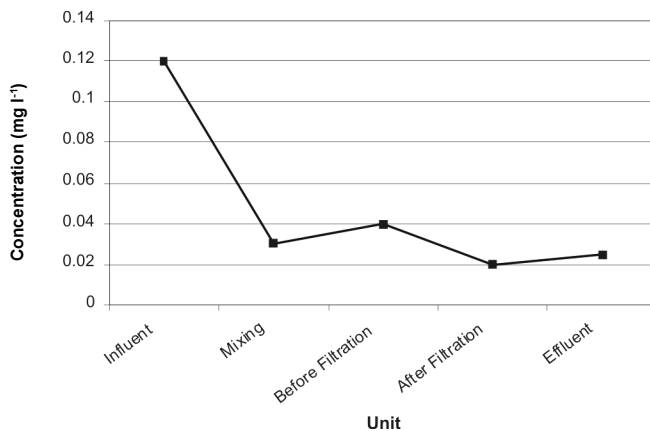


Figure 3: Copper variation during water treatment process.

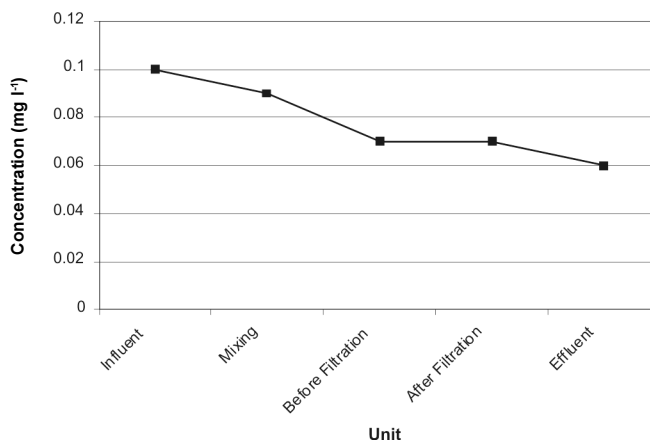


Figure 4: Nickel variation during water treatment process.

2.03 mg l⁻¹, whereas in the samples in effluent of plant was 2 mg l⁻¹ (Figure 5). Results showed that the concentrations of aluminium in all the water samples from the water treatment plant exceeded the EPA drinking water standard. The EPA drinking water standard for aluminium is 50 µg l⁻¹ (APHA, AWWA and WPCF, 1995). The presence of aluminium in influent of the water treatment plant is due to the leakage of aluminium from concrete of the canal before reaching the water treatment plant, or is caused by a low pH value of raw surface water. The levels found naturally in raw surface water ranged from about 10 to 2000 mg l⁻¹ (Srinivasan et al., 1999). Aluminium levels in areas where surface waters have become acidified (pH ~ 4 to 5) were in excess of 40000 mg l⁻¹ (Srinivasan et al., 1999). The most elevated aluminium concentrations were found in the influent of the filtration unit (mean of 2.96 mg l⁻¹).

During conventional water treatment processes, aluminium undergoes various transformations (also called speciation of aluminium) which are influenced by factors such as pH, turbidity, temperature of water source, and the organic and inorganic ligands present in water (Srinivasan et al., 1999). Hence, it is clear that there was little change in total aluminium concentration during treatment. Surveys of aluminium speciation by Gardner and Gunn (1991) have also shown similar results. The same survey on different raw surface water sources and treated water showed that the raw water aluminium was predominantly in particulate form (Srinivasan et al., 1999; Bodek et al., 1988). However, for many water supplies (particularly where aluminium is used as coagulant), the total aluminium concentration increases after treatment.

There is reported to be a 40 to 50% increase in aluminium concentrations in drinking water over the concentrations in the raw water in plants using Al-based coagulants (Miller et al., 1984). Temperature, pH and turbidity of the water are important factors in determining aluminium solubility and consequently residual aluminium. As an operational tool to minimize aluminium residuals in finished water, local utilities of Isfahan city should consider determining relationship between residual aluminium and turbidity in their water. Similar results were reported by Jakel (1991) about correlation between residual aluminium and effluent turbidity.

Conclusion

The removal efficiency of heavy metals including iron, manganese, copper and nickel surveyed in various units of water treatment plant in Isfahan City were studied. The results showed that removal efficiency of iron, manganese, copper and nickel were 71, 60, 79 and 40 percent, respectively. In this paper it has been shown that metal reduction to levels below internationally approved guidelines is possible using conventional treatment technology. Experimental results currently showed low efficiency for the suitable removal of aluminium. So, the aluminium concentration in all the samples from the influent (2.03 mg l^{-1}) and effluent (2 mg l^{-1}) of the water treatment plant exceeded the EPA drinking water standard ($50 \text{ } \mu\text{g l}^{-1}$).

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