Evaluation of the biocidal effects of activated carbon filter supporting silver

Kyong Whan Moon, Young Whan Kim, Dal Woong Choi

Dept. of Environmental Health, College of Health Sciences, Korea University, Seoul, 136-703 Korea

Abstract

The objectives of this study are to investigate the relationship between the silver ion concentrations released from the point-of-use(POU) water purification devices installed silver impregnated activated carbon filters and the antibacterial activities against HPC bacteria. Total of 68 POU devices were tested. The concentrations of the eluted silver ion from the silver impregnated activated carbon filter showed the range from 4 μg/L to 386 μg/L, and the HPC bacteria were found to diversely grow within the range 0-5,200 cfu/mL. The average silver concentrations released from UF units system and RO units system were 30 μg/L and 73μg/L, respectively. And the number of colonies were reduced significantly as the elution levels of silver exceeded 100 μg/L, however silver ions below the concentration of 100 μg/L were not particularly effective for eradicating HPC bacteria from water.

Introduction

The employment of point-of-use(POU) home water purification devices is well-established in Korea due to an increased awareness of drinking water pollution and the continuing demand for aesthetically pleasing water.

Activated carbon filters have been widely used in most of the water purification systems to remove organic contaminants and constituents that cause taste and odor problems from the tap water. But since it has been known that activated carbon filter was able to foster bacterial growth on the trapped organic substances and to release those bacteria into the water. In several studies, it was reported that some of the most widely used POU home water purifier produced tenfold or higher effluent heterotrophic(HPC) bacteria than detectable in the influent water. In response to these problems, new antibacterial technologies were required, and the applications of metal on the activated carbon, especially silver, were attracting considerable

attention. It is well known that silver ions and silver-based compounds are selectively toxic to microorganisms, showing strong biocidal effects on several species of bacteria including *E. coli* and *Pseudomonas aeruginosa.*

Therefore, this study aim to characterize and evaluate the relationship between the silver ion concentrations released from the POU devices installed silver impregnated activated carbon filters and the antibacterial activities against HPC bacteria.

Materials and Methods

To examine the relationship between the silver ion amounts releasing from the silver impregnated activated carbons and the properties of growth of HPC bacteria, total of 68 POU devices were tested, which devices had been usually installed at the corner of the school corridor and attached to the faucets. Volumes of 100 ml water samples were taken in sterile flasks at the outlet of each filter cartridges. 1 ml of collected sample was mixed into molten standard plate count(SPC) agar and allowed to solidify. SPC plates were incubated at 35℃ for two days and counted.

The silver ion contents were measured by inductively coupled plasma mass spectrometry (ICP-mass, Agilent 7500a, USA). HPC bacteria were counted by previously mentioned same conditions.

Results

The properties between the silver amounts releasing from the silver impregnated activated carbons and HPC bacteria in each effluent from the POU devices showed Fig 1.

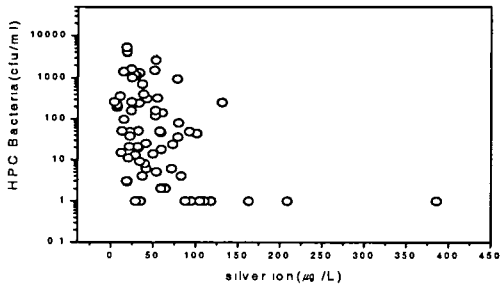

Fig. 1. Silver amounts releasing from the activated carbons and HPC bacteria.

The concentrations of the eluted silver ion from the silver impregnated activated carbon filter showed the range from 4 μg/L to 386 μg/L, and the HPC bacteria were found to diversely grow within the range 0-5,200 cfu/mL. The public health standard for HPC bacteria in drinking water is regulated as 100 cfu/mL in Korea.

The correlation between the concentration of silver from the water samples and the HPC bacteria showed not significantly. And the number of colonies reduced significantly as the elution levels of silver exceed 100 μg/L, however silver ions below the concentration of 100 μg/L were not particularly effective for eradicating HPC bacteria from water.

Generally, it has been known that silver ions were showing strong biocidal effects on several species of bacteria including *E. coli* even the level of 20 μg/L. But several species among HPC bacteria are not susceptible to the silver ions, and then become grow on the occasion of high concentrations of silver ion. Thus to know the kinds of microorganisms in the water is important to achieve proper inactivation against the bacteria.

Table 1 showed the amounts of releasing silver ions from the total of 68 POU devices. Devices were classified into two groups. One group was UF units system, which was consisted of four filter cartridges systematically, mechanical sediment filter, pre-activated carbon filter, ultra filtration (UF) membrane, and silver impregnated post- activated carbon filter. Another group was RO units system, which was replaced UF by reverse osmosis filter. The average silver concentrations released from UF units system and RO units system were 30 μg/L and 73μg/L, respectively. The amounts of silver ions in the water passed through RO units system showed about 2.5 times higher than that of UF system units.

Table 1. The concentrations silver ions released from the each different POU devices.

Type	No.	mean ±SD (μg/L)	Range (μg/L)
UF	29	30±18	4-58
RO	39	73±66	24-386
total	68	55±56	4-386

Fig. 2 showed the pH of the water passed through the POU devices. The pH ranged from 7.0 to 7.6 on the occasion of UF systems, but pH of the effluents taken

from the RO system units showed low within the range 5.6~7.4.

Thus, elevated levels of silver ion could be explained that the pH of permeated water through reverse osmosis filter was low due to concentrated dissolved carbonic acid gas, and so the solubility of silver contained post-carbon filter was increased as the pH decreased.

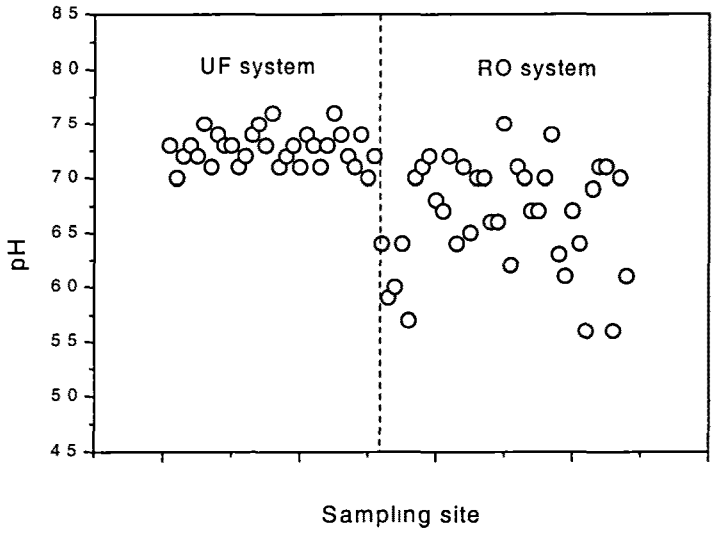

Fig. 2. pH of the water passed through the POU devices

Conclusion

Silver impregnated activated carbon filter is using to inactivate the bacteria inhabited on the point-of-use(POU) water purification devices. But the releasing properties of the silver ions from those filter and the growth of heterotrophic(HPC) bacteria depend on the constitution of POU devices, kinds of microorganism to be proliferated, and the period of use on each filter. The amounts of silver ions released from RO units system were higher than that of UF system units, and several occasions were exceeded the value of the standard. HPC bacteria from water were reduced significantly as the elution levels of silver exceed 100 μg/L, however silver ions below the concentration of 100 μg/L were not particularly effective.

References

Haeeun Kim et al. Control of bacterial growth in water using synthesized inorganic disinfectant, Chemosphere 55 : 775-780, 2004.

Ivan Sondi et al. Silver nanoparticles as antimicrobial agent : a case study on E. coli as a model for gram-negative bacteria, Journal of Colloid and Interface Science, 2004.

Kathleen Parrott, Blake Ross, Janice Woodard, Household water treatment, Housing, 356-481, 1999.

Kelly A. Reynolds. HPC bacteria in drinking water, Water Conditioning & Purification, 90-93, 2002.

Wadhwa S.G et al. Comparative microbial character of consumed food and drinking water, Critical Review in Microbiology, 2002.