Relationship between Bacterial Regrowth and Free chlorine Residuals in Water Distribution System

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Abstract

This study is to observe the occurrence of heterotrophic bacteria in terms of free chlorine residuals in two different water distribution system which belongs to both *K* and *Y* water treatment plant of S city of Korea. The data analyzing in distribution systems (DS) shows that the free chlorine residuals decrease from 0.10 to 0.56 mg/L for K, and 0.51 to 0.78 mg/L for Y. The decay of free chlorine is clearly higher in both March and August than those of in January. The HPC in DS are ranged from 0 to 40 CFU/mL for K, 0 to 270 CFU/mL for Y, on R2A medium. In particular, its level is relatively high at consumers ground storage tanks, taps and point-of-end area of Y.

The predominant genera is studied in distribution systems are *Acinetobacter, Sphingomonas* (branch of *Pseudomonas*), *Micrococcus, Bacillus, Staphylococcus*. The diversity of heterotrophic bacteria increase in the end-point area. Most of them are either encapsulated cells or cocci of gram-positve. In conclusion, the point-of-end area in distribution systems shows the longer flow distance from water treatment plants, the greater diversity and higher level of heterotrophic bacteria due to the significant decay of free chlorine residuals.

Introduction

It is not possible to supply the safety tap water in case of the problem of pipe corrosion and contamination by microbe while the purified water through by distribution systems. Therefore, the systematic control of distribution system which includes not only the process of water treatment and quility control of source water but the process from the water treatment plant to the consumers tap is need to supply the good quality water. The contamination source in distribution systems make worse the water quality, and is mainly inflow from the open finished water reservoir and damaged and bad-junction pipe. There are many reports that the excessive bacteria detection shown in tap water contrary to the water treatment plant which was not detected, and the reason is presented by the regrowth of bacteria.

This study is mainly focus on the method of stable control of the quality of water in

distribution systems of the tap water by means of the evaluation of heterotrophic bacteria in terms of free chlorine residuals for the K and Y water distribution systems which belongs to S city in Korea. Also, this study investigates the predominant heterotrophic bacteria and distribution of microorganisms by elements of facilities in the mentioned distribution systems.

Materials and Methods

Sample Collection

The sample collection of this study is done by the point of water reservoir, underground water reservoir, water tank, and tap as shown in Table 1 for the K and Y distribution systems which differs each structures. The sample bottle includes the 3% of sodium thiosulfate($Na_2S_2O_3$) in order to neutralize chlorine residuals, and is sterilized by high pressure steam. In order to prevent the infection from the outside, the sample is produced by flames and sterilizing without filters, rubber hose, and the inside deposits of pipe is drained by 2 to 3 min.

Table 1. Sampling sites in distribution systems

	Sites	Distance from water works plant (km)	Retention time (min)	Characteristics
K distribution system	Finished water Reservoir	10.5	166	K water works plant 10,000 ton
	Tap water without storage tank	14.0	203	
	Storage tank	14.1	143	1,100 ton
	Tap water with storage tank	14.2	510	
Y distribution system	Finished water Reservoir	7.5	496	Y water works plant 50,000 ton
	Small Reservoir	14.2	743	500 ton
	Tap water without storage tank	14.4	748	
	Storage tank	14.5	839	2 ton
	Tap water with storage tank	14.5	840	

Results and Discussion

The seasonal variations of heterotrophic bacteria for the target area of K and Y distribution systems are shown in Fig. 1 and Fig. 2. The variation of K distribution systems in January is 0~4 CFU/mL and the Y distribution systems is 0~270 CFU/mL. In March, the K distribution systems is 1~43 CFU/mL and the Y distribution systems is 1~86 CFU/mL. In August, the K distribution systems is 0~40 CFU/mL and the Y distribution systems is 0~12 CFU/mL.

Therefore, the density of heterotrophic bacteria of the Y distribution systems are higher than that of the K distribution systems through whole seasons, and the distribution of heterotrophic bacteria is contrary to the density variation of free chlorine residuals about the temperature condition for both cases. The maximum values of heterotrophic bacteria of the K and Y distribution systems are January, March respectively.

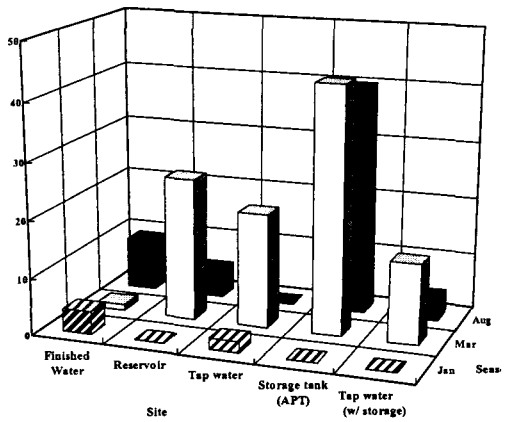

Fig. 1. HPC in K distribution systems.

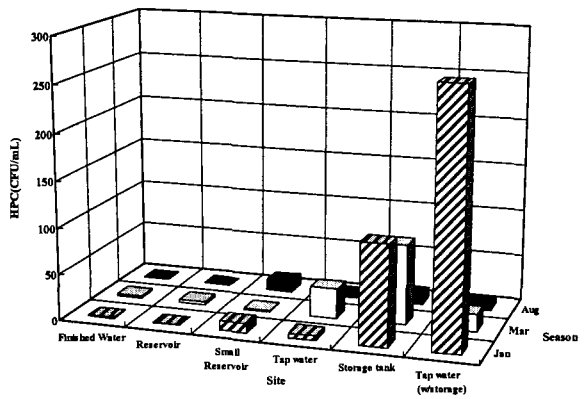

Fig. 2. HPC in Y distribution systems.

Sphingomonas, Micrococcus, Bacillus, Pseudomonas, Acinetobacter, Staphylococcus, Acidovorax, Gordona, Corynebacterium, Arthrobacter, Cellulomonas, Agrobacterium, Deinococcus, Methylobacterium, Hydrogenophaga, Bradyrhizobium, Aureobacterium, Curtobacterium, Variovorax are detected by the identification of heterotrophic bacteria with MIDI after the extraction of fatty acid in the cell.

The optical microscopic structure of the heterotrophic bacteria are shown in Fig. 3 and Fig. 4. The heterotrophic bacteria has a suitable structure to grow in distribution systems, and contains 50% of the gram positive bacteria which has strong tolerance to the disinfectant. Especially, the bacteria in finished water and reservoir is almost the form of bacillus, but *Staphylococcus, Micrococcus* are largely detected in near the point-of-end area as for the micrococcus which has strong tolerance to the disinfectant.

Acinetobacter is the bacillus as gram negative which has the capsule, and the capsule seems to operate as the protection membrane. *Bacillus* has the gram positive and capsule structure. On the other hand, *Staphylococcus* is the gram positive, and *Sphingomonas, Flavobacterium* are the gram negative. Almost the heterotrophic bacteria in distribution systems of tap water consists of the capsule structure and the gram positive instead of capsule which has a strong tolerance because of the distinct layer of peptidoglycan.

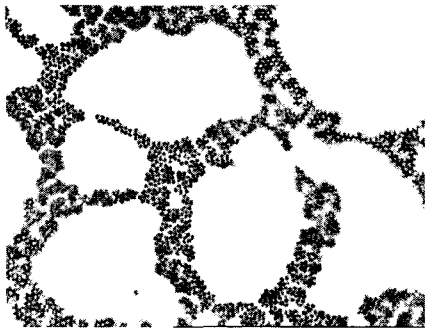

Fig. 3. Photograph of identified coccus (*Staphylocuccus*)

Fig. 4. Photograph of identified bacteria containing capsule (*Acinetobacter*)

References

1. Charaklis, W. G., and Marshall, K. C. : Biofilms. John Wiley & Sons Inc., New York, USA, 20-36, 1990.
2. LeChevallier, M. W., Babcock, T. S., and Lee, R. G. : Examination and characterization of distribution system biofilms. *Appl. Environ. Microbiol.*, 53, 2714-2724, 1987.
3. Lee, Y. J., Jo, K. H, Choi, J. H and Nam, S. H. : Evaluation of Chlorine Demand and Chlorine Decay Kinetics for Drinking Water. *Kor. J. Env. Helth. Soc* (in Korean), 27, 27-35, 2001.
4. Lee, Y. J., Lee. B. S., Lee, S. J and Nam, S. H. : Kinetics and Factors Affection Disinfection by Chlorine in Drinking Water. *Journal of Korean Society of Environmental Engineers* (in Korean), 23, 555-563, 2001.
5. Payment, P., Gamache, F. and Paquette, G. : Comparison of microbiological data from two water filtration plants and their distribution system, *Water Sci. Technol.*, 21, 287-289, 1989.