**Survey on micro-particles adhered inside water distribution pipes**

and a distribution of accumulated matters in a network

*J.Kishimoto\*1), T.Nakanishi1), X.Zhou1), H.Nishioka2), J.Kitada1), K.Tarui1), Y.Hashimoto1),*

*Y.Asada1), S.Echigo3), S.Itoh1)*

*1)Department of Environmental Engineering, Graduate School of Engineering, Kyoto University, C-1 Kyotodaigaku-katsura, Nishikyo-ku, Kyoto 615-8540, Japan*

*2)Sekisui Chemical Co., Ltd., 2-4-4 Nishi-tenma, Kita-ku, Osaka 530-8565, Japan*

*3)National Institute of Public Health, 2-3-6 Minami, Wako, Saitama 351-0197, Japan*

*\* Corresponding author’s email address: vipest.tsuboy@gmail.com*

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Introduction

In a depopulation society, water velocity in water distribution pipes can decrease because of the decrease of water demand. This can promote micro-particles in the treated water to adhere to pipe surface and cause deterioration of water quality inside network. Therefore controlling its quality is essential in the future. The function of self-cleaning in distribution pipes and earthquake resilience for redesigning water distribution system was evaluated for this purpose (Hirayama et al, 2016; Yamada et al, 2014; Wada et al, 2014). These evaluation were based on a presupposition that we can control the adhesion of particles to pipe wall by increasing water velocity, however, there are not enough evidence. Thus the amount of accumulated matters in a network should be an important indicator. The main objective of this article is to observe the actual condition of the accumulation in a water distribution network by field survey and to evaluate the controllability of accumulated materials by estimating amount of accumulated matters with a numerical model.

Methods

Field study

The survey was conducted in A City from October to December 2016. We collected flushing water samples and then measured its concentration of SS and estimated the amount of accumulated matters. Flushed water was discharged with high velocity (above from 0.3 m/s to 0.5 m/s) after making pipes isolated in a line by handling surrounding valves. The concentration of SS was measured by filtering flushed water sample. Then we calculated its amount in the pipe wall with Eq 1. Since target matters in this article are those flown from a water treatment plant, Fe included in SS was excluded from calculated amount because most of Fe in SS was considered rust.

*Amount of SS(g/m2)=Concentration of SS(mg/L)×flow(m3/hr)×duration(hr)/Internal area(m2)* (1)

Estimating Accumulation

The amount of accumulated matters was estimated in the same network as field study. Standard EPANET and its expanded module EPANET-MSX developed by USEPA were used for the simulation. There were two assumptions when a set of model formulas was made. One is that adhesion rate of particles is in inverse proportion to water velocity (Thienen et al, 2011), and another is that amount of accumulated matters is monotonously increasing and never desorb. The equations used with these assumptions for the estimation are as follows.

|  |  |
| --- | --- |
|  | (2) |
|  | (3) |

CL: concentration of particles in bulk water (mg/L), CS: amount of accumulated matters (g/m2), V: water velocity (m/s), K: adhesion rate constant (m/s2), Av: surface area for unit volume (m2/L)

At first we searched suitable value of adhesion rate constant K for estimation by comparing the amounts of surveyed sediments and those of estimated ones in the same area. Then we calculated the amount of accumulated matters in both the current distribution network and the redesigned one and then evaluated the effect on decreasing accumulated matters in the network. The network was re-designed by reducing diameter of all pipes by one step.

Results and Conclusions

The results of field study are shown in Table 1. The concentration of SS in flushed water was ranged from 8.6 mg/L to 31.1 mg/L. The amount of accumulation on pipe surface was calculated from 0.67 g/m2 to 3.79 g/m2. The amount of loose deposits excluding Fe was varying from 0.45 g/m2 to 2.34 g/m2, decreased about 30 to 60%.

**Table 1** Results of field study

result of survey

Table 2 shows the results of estimation in both current network and diameter-reduced one. Duration was 10 years. The total internal area of the network decreased from 6.14×104 m2 to 4.66×104 m2. Total amount of accumulated matters was also decreased from 130 kg to 76 kg. It was found that amount of accumulation per unit area was significantly decreased from 2.13 g/m2 to 1.63 g/m2.

The main outcomes of this study are to show a distribution of accumulated matters in a water network as shown in Figure 1, which demonstrates the distribution of accumulated matters in current network, and evaluate change of the amount of accumulated matters. However there are lots of problems because of the luck of information in this stage of research. Therefore we need to obtain more information about a relationship between water velocity and adhesion of micro-particles and improve model formulas by articles or lab-scale adhesion experiments.

**Table 2** Difference of the amount of accumulation and internal area between current and redesigned network.

縮径前後の変化表english

**fig_distribution_of_accumulated_matters**

**Figure 1** Distribution of the amount of accumulation in current network

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