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Particle accumulation rate of drinking water distribution systems determined by incoming turbidity

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Abstract

Particulate material accumulates in drinking water distribution systems (DWDS) and this can cause discolouration. To minimize customer complaints it is required to understand the influencing factors and determine an appropriate flushing frequency. The accumulation rates of two comparable DWDS were examined. Area A with a constant incoming water quality experiences a steady accumulation rate; area B with a more variable incoming water quality has a variable accumulation rate. The difference in accumulation rate is proportionate to the difference in the particle loading of the two areas and is thus largely determined by the difference in incoming water quality. The water quality into a DWDS is not only determined by the treatment works, but also by the material accumulation and resupsension in the trunk mains supplying it. Monitoring the particle loading of a DWDS part can help in determining the required flushing frequency.

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Keywords: Drinking water distribution, discolouration, temperature, fouling rate

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1. Introduction

It has been demonstrated that particulate material accumulates on pipeline surfaces in drinking water distribution systems (DWDS) and that when mobilized this material can cause discolouration and other water quality issues. Discolouration is the main reason customers complain about the water quality (Vreeburg and Boxall 2007). Vreeburg (2007) has shown that the discolouration risk is caused by particulate material and that it can be reduced with three types of measures: the first is to prevent material from entering the DWDS by optimising the water treatment (Husband and Boxall 2011; Vreeburg 2007); the second is to prevent material from accumulating in the DWDS, for example by designing self-cleaning networks with daily flow velocities that prevent residence (Blokker et al. 2007) and the third is to remove material by cleaning (e.g. flushing) the DWDS in a timely manner (Vreeburg 2007). In existing networks the first and second measures are typically capital expensive, so in practice a drinking water company will likely choose flushing. Material accumulation however is not equally distributed over the DWDS; some areas may foul faster than others. In order to prevent discolouration events timely flushing is required. But there are currently no tools to determine the optimal flushing frequency of a network. Waiting for customer complaints means that only reactive cleaning is done. More pro-active cleaning can be done by determing the discolouration risk via e.g. the RPM method (Resuspension Potential Measurements) (Vreeburg et al. 2004). In the Netherlands the flushing frequency of a network is based on water quality complaints and/or RPM. Water company PWN performs on average one RPM per 12.5 km of pipe, where the local result is assumed to be representative of the discolouration risk of a larger network. This is disputable as local circumstances such as pipe material, flows and regular boundary wall shear stresses may affect localised particle accumulation (Husband and Boxall 2009). In order to design an optimal flushing programme it is required to understand the factors that influence the accumulation rate.

In a previous study (Mounce et al. 2015 , in press), a data-driven modelling approach was used to determine which factors influence the rate of discolouration material accumulation (RoDMA) in the DWDS, as described by total turbidity removed with flushing. This approach showed that next to bulk water iron concentration and pipe material, the temperature was an important factor in a Dutch DWDS. Also, it showed for the Dutch case study that the previous RoDMA was an excellent predictor; this means that the RoDMA seems to be fairly constant over time for a given network.

For two areas in PWN's DWDS the RoDMA was monitored over 6 years. The two areas in the DWDS are comparable. Both serve approximately 2000 households and have a similar composition of pipe diameters and materials (mainly Ø100 mm AC, approximately 10 km total pipe length); the average estimated residence time in both is 6 hours. The flow velocities in the pipes are also similar. The two areas are adjacent and a similar incoming water quality is expected. One area showed a repeatable RoDMA, but the other showed a large variation (Blokker et al. 2011a). And, even though the two areas seemed very similar, the RoDMA of the two areas is not the same. As neither the network configurations nor the demands changed over time, we investigated if the incoming water quality may be the reason for the changes in RoDMA, i.e. if the incoming water quality is different for the two areas and if it has changed over time and if this could explain the difference in RoDMA.

2. Methods and materials

2.1. Research areas

Two areas in Purmerend in the Netherlands were studied. The Provincial Water Company North-Holland (PWN) built this network between the late 1960s and early 1980s. It is a conventional residential DWDS with large enough pipe diameters to supply the required fire flows. In 2006-2008 Purmerend had, from a Dutch perspective, a relatively high average of 1.5 discoloured water complaints per 1000 connections per year (Schaap and Drevijn 2009). The network was flushed in October 2008 and again in March 2010, October 2010, August 2013 and October 2014. From the decrease in discolouration complaints (Blokker et al. 2011b; Blokker et al. 2010) it was concluded that the cleaning of October 2008 was effective. The exact event history prior to October 2008 is unknown; it was last flushed approximately ten years before the measurements of 2008. No breaks occurred in this network; only some local work was done in repairing leaks, replacing a hydrant, or a section was isolated because work was done on e.g. crossing sewers. Furthermore, no hydrants were knowingly used for purposes other than the RPM measurements and