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Temperature influences discolouration risk

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Abstract

Particulate material can accumulate in drinking water distribution systems (DWDS) and can cause discolouration. Previous research showed that temperature influences this. However, it did not explain why higher temperatures lead to a higher accumulation rates. Based on existing data collected in the DWDS of several Dutch water companies, we investigated if higher temperatures lead to more particulate material from the treatment plant, or cause higher accumulation rates within the DWDS. Continuous temperature and turbidity measurements at 6 pumping stations showed the majority of the treatment plants do not have a seasonal trend in turbidity. Filter volumes in the DWDS and high frequency particle accumulation rate measurements on numerous locations in the DWDS of one specific water company did show a seasonal effect. It is likely that higher temperatures in the DWDS can augment particulate material accumulation.

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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 (Husband and Boxall 2009; Vreeburg and Boxall 2007). In order to minimize customer complaints it is required to understand the factors that influence the accumulation rate.

There is a suggestion that there are more discolouration complaints during higher temperatures (Cook et al. 2015). These were not caused by higher burst events or higher water demands. In a previous study (Mounce et al.

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2015 , in press), a data-driven modelling approach was used to determine which factors influence the rate of discoloration material accumulation 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. Others have shown that the biofilm potential is higher at higher temperatures (Hallam et al. 2001).

However, it is not yet clear why higher temperatures lead to a higher discolouration risk. Blokker and Pieterse-Quirijns (2013) have shown that the drinking water temperature in the DWDS is largely influenced by the temperature of the surrounding soil. For transport mains there is still some influence of the temperature with which the water leaves the water treatment works (WTW), but in the distribution part the effect of soil temperature is dominant. In the Netherlands, where distribution pipes are typically installed at 1 meter depth in sandy soils, this means that the drinking water at the tap ranges from 5 °C in winter to 22-25 °C in summer. This means that when there is no seasonal variation in temperature from ground water supplies at the WTW, there will be one in the DWDS. This may also mean that if there is no seasonal effect in turbidity from the WTW, there may be one in the DWDS.

In this paper, we further investigate if the temperature causes higher loading of the DWDS, meaning that more particulate material is entering the DWDS from the treatment plant at higher temperatures, or that higher temperatures within the DWDS cause higher accumulation rates. We have used existing data as it was collected by several Dutch water companies. Based on these data, a hypothesis was formulated that needs to be tested with new measurements. This preliminary study shows which measurement techniques are useful for the next phase.

2. Methods and materials

2.1. Water treatment works

The loading of the DWDS from the water treatment works (WTW) or pumping station (PS) with particulate material is determined by the turbidity, which relates to the concentration of material, multiplied by the flow rate. The weekly average turbidity, determined from on line measurement with a time interval of 10 to 15 minutes, of several PS from different water companies, all surface water, were analysed (Table 1). For most of the time the turbidity values at the PS were quite constant over the day and because on line flow measurements were not available for all of the sites, the turbidity was analysed instead of the mass loading (turbidity * flows).

Table 1. Overview of temperature and turbidity data from surface water pumping stations.

	PS Hoorn	Berenplaat	Kralingen	Weesperkarspel	Leiduin	PS Osdorp
Water Company	PWN	Evides		Waternet		
Measurement period	Jun 2013 – Dec 2014	Jan 2008 – Dec 2011		Jan 2013 – Dec 2014		
Data integrity	The turbidity meter showed measurements errors due to condense in the measurement chamber. Values above 0.15 FTU were discarded in the week average.	No remarks		The turbidity meter showed some high values that were interpreted as measurements errors during only a few weeks. Values above 0.2 FTU were discarded in the week average.		Temperature summer 2014 incorrect; two months of turbidity data missing in Q2 2014.

2.2. Transport mains

At several locations along the transport system towards Volendam (Table 2) in the Hoorn supply zone online turbidity was measured. This was done with a measuring lance that extracts water from the bottom, centre and top of the main and the mixture of this water was fed to a turbidity meter. In the Waternet supply zone on-line turbidity and temperature were measured at two locations (Table 3); the water is drawn from the top of the pipes.

Again, at the transport mains, we only analysed turbidity instead of mass. At transport mains flow is not measured; alternatively values from a hydraulic model may be used. PWN provided 15 minute time step data for flow for measurement location 1 (Beemster) from the hydraulic model. We found that the average of (flow *