TEMPERATURES IN DRINKING WATER DISTRIBUTION SYSTEMS: QUANTIFYING MEASURES TO LIMIT WATER QUALITY EFFECTS

Mirjam Blokker[1], Ilse Pieterse-Quirijns[1]
[1]KWR Watercycle Research Institute, Nieuwegein, the Netherlands

Abstract

In the Netherlands, the drinking water is distributed without disinfectant residual. According to the Dutch Drinking Water Directive the temperature of the drinking water at the customers' tap is not allowed to exceed 25 ºC. The reason is that at higher temperatures regrowth of micro-organisms, such as *Legionella*, may occur. Occasionally (0.03%), samples at the tap do exceed this limit and with higher outside temperatures the exceedance increases. With global warming, the limit of 25 ºC may be exceeded more often. Dutch Water Companies are interested in measures that may reduce the temperature at the tap or that restrict the negative consequences of the higher drinking water temperature.

The purpose of this paper is to study the effectiveness of different measures based on a model that predicts the temperature of the drinking water and microbial evolution in the distribution network from weather data. Modelling the temperature change in the drinking water distribution system provides insight into the most important parameters in this process. Moreover, it contributes to assess the consequences of all temperature related processes in the distribution network.

The used temperature models consists of two parts: a model that predicts the temperature of the soil surrounding the drinking water main and a model that predicts the resulting drinking water temperature, schematically shown in Figure 1.

The temperature of the soil around the drinking water mains changes under influence of atmospheric temperatures and solar radiation. The rate of temperature change depends on wind velocity, the absorption coefficient of the ground coverage, and the thermal conductivity and specific heat capacity of the soil. With a simple heat flux model the soil temperature can be predicted based on weather forecast data.

The water in the drinking water distribution system approaches the soil temperature with a rate that depends on the heat conductivity of the pipe material and flow velocity. For heat conductive pipe materials, both the travel time and the heating time are inversely proportional to the flow velocity. For heat insulating pipe materials the heating time is mainly determined by the pipe diameter. EPANET MSX was used to model the water temperature in the drinking water network.

Drinking water temperature may affect the water quality. In this case the water temperature at the tap is not the most important parameter. The cumulative effect of the water temperature between the water treatment and the tap is more important. Therefore, a temperature related growth curve of two fictitious micro-organisms was modelled in EPANET MSX. One model micro-organisms has an optimum growth rate at 25 ºC, the other at 37 ºC. The cumulative effect of both temperature and residence time on the number of micro-organisms can thus be studied.

With the help of the soil temperature model and the drinking water temperature model the influence of all model parameters on the temperature of the water at the tap and on the growth of the fictitious micro-organisms were quantified. The parameter values were changed within practically achievable ranges:

- The weather condition in 2003 was translated to the weather condition in 2050.
- Soil type was varied between clay, sand, peat and mixtures of these.
- The surface was either paved or covered by vegetation
- The albedo of the paved surface was varied between 0.1 (red bricks) and 0.4 (smooth light coloured concrete).
- The depth of the water mains was varied between 0.5 and 2.0 m.
- The pipe material was varied between cement coated cast iron and PVC, with variable wall thickness (from manufacturers catalogues).
- The pipe diameter was decreased while maintaining pressure constraints.
- Different locations of cooling: ingoing drinking water at pumping station, local cooling in district, local cooling in street
- The residence time was varied by applying 10 % extra demand over the day or only during the night time.

The most effective practical measures, with respect to keeping the temperature below 25 ºC and limiting the growth of micro-organisms, are laying the pipes deeper (at least 1.2 m) under vegetation or under paved surface with higher albedo, reduce the residence time for example by using smaller pipe diameters and use heat insulating pipes (PVC pipes with larger wall thickness).

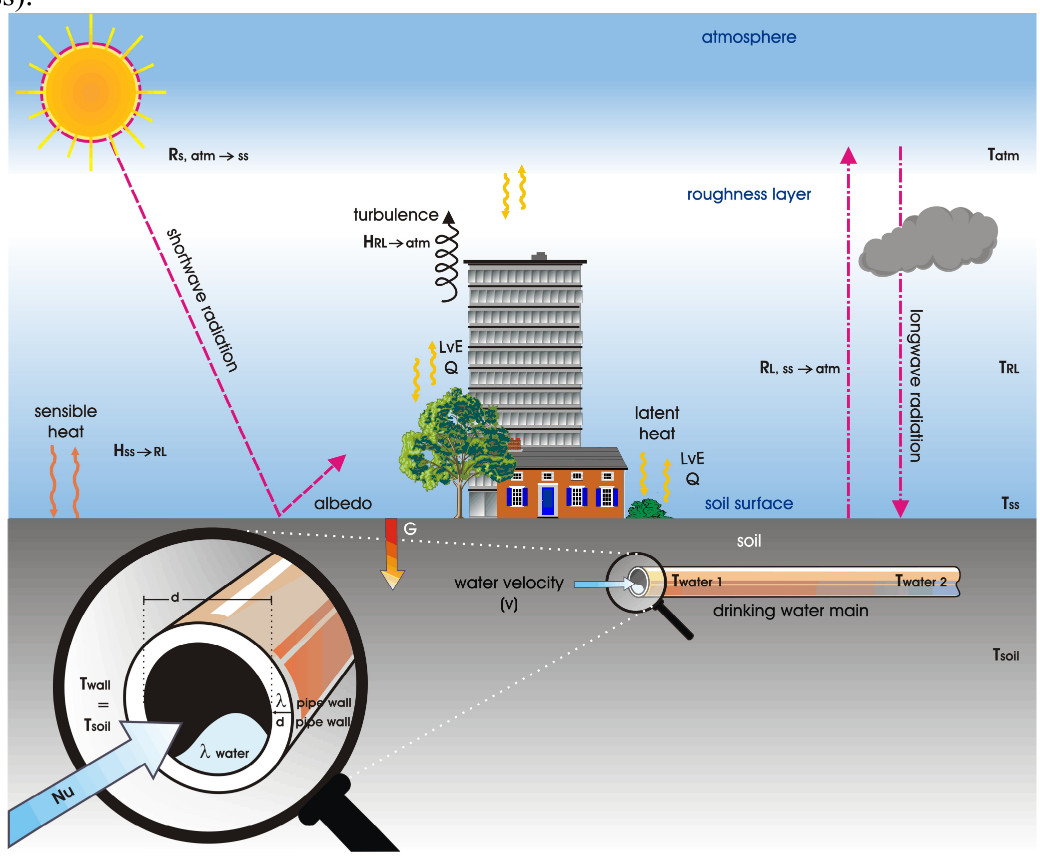

Figure 1 Schematic representation of heat transfer from atmosphere, through soil to the water in the drinking water distribution system (DWDS).