Removing deposits, biofilms and animals from drinking water distribution networks - new tasks as a result of climate change?

From Norbert Klein

1 Introduction

The drinking water distribution network habitat was the subject of the previous lectures [1, 2]. This presentation first describes some general aspects of this topic and then provides information on new findings on the removal of deposits, biofilms and animals from pipes.

2 General aspects

The requirements of the Drinking Water Ordinance [3] show that our drinking water is not sterile. Appendix 7 contains the following limit values for the indicator parameters for the colony count:

– Colony count at 36 °C: 100 CFU/ml
– Colony count at 22 °C: 100 CFU/ml at the consumer's tap
– Colony count at 22 °C: 20 CFU/ml immediately after completion of treatment in disinfected drinking water.

A thin, firmly adhering biofilm (colonization) is desirable on the materials in the drinking water sector. According to DVGW W 270 (A) [4], colonization is an indication that no biocides are transferred from the materials into the drinking water. However, voluminous colonization is only permitted up to certain limit values. This is an important prerequisite for ensuring that no parts of the biofilm detach during operation and impair the water so that clean drinking water reaches the consumer after transportation through the pipe network.

Most drinking water distributed in Germany does not contain any disinfectants. Pipe networks are living, even living systems that are nevertheless supposed to deliver pure drinking water to consumers. To keep it that way, it is necessary to maintain control over it. Drinking water is the most studied foodstuff. Under certain conditions, however, it is quite possible for the limit values to be reached or even exceeded during treatment, and even for animals as well as microorganisms to get into the drinking water. The first countermeasure is usually drinking water disinfection. However, experience has shown that neither drinking water nor system disinfection is effective. This is because the causes of the problems [1, 2] remain. Other solutions are necessary.

One important aspect with regard to climate change is the installation depth of the pipes. As a result of reduced frost depth and due to economic considerations, the installation depth of pipes has been reduced in recent years.

pipes were installed less deeply. The hygienic aspect was obviously overlooked. Lower installation depths mean higher water temperatures, especially in summer. However, higher water temperatures lead to accelerated reactions. Deposits and biofilms form more quickly than at lower temperatures. Cleaning is necessary to restore the pipeline to the hygienically and hydraulically perfect condition it was in when it was first put into operation. One effective measure is intensive cleaning using mechanical processes. The pulse flushing process has proven itself here.

Another aspect is the ochre build-up in raw water pipes. Ochre in these pipes impairs the flow and increases the energy required for pumping. Ochre can be produced either by chemical oxidation with atmospheric oxygen or by microbial processes. Microbial ochre formation is the subject of a BMBF joint project, project coordinator Prof. Dr. U. Swewzyk, TU Berlin, Department of Environmental Biology [5]. The aim of this project is to identify and characterize bacteria that deposit oxidized iron compounds at a neutral pH value. The overall aim of the joint project is to gain a better understanding of the process of clogging in technical systems and to develop new methods for preventing or dissolving clogging on the basis of the data and parameters to be determined. One sub-project deals with the effectiveness of the Comprex impulse flushing process for removing clogging from raw water and well pipes as well as risers [6].

3 Cleaning using the pulse rinsing method

The impulse flushing process for the intensive cleaning of pipes is now one of the generally recognized rules of technology [7]. Hammann has further developed this process into the Comprex process. It is based on a controlled, pulse-like addition of compressed, quadruple-filtered air into a defined pipe section (Fig. 1).

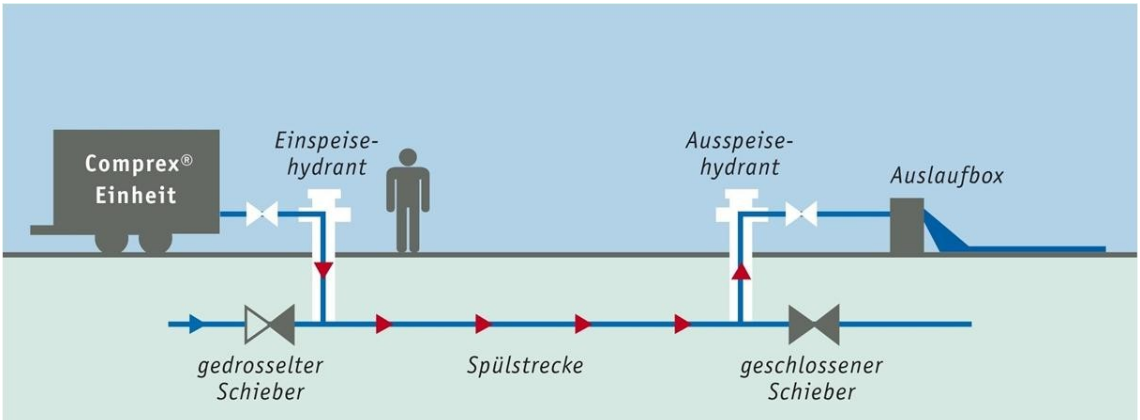

Figure 1: Removing deposits from pipes using the pulse flushing method

The air blocks that form at the feed point move alternately with water blocks through the pipe section). The slide valve at the start of this pipe section reduces the flow velocity of the incoming water (Fig. 1). The air for the air pulses has a higher pressure than the water column. Therefore, the air pulses accelerate the water blocks already present in the pipe to over 15 m/s when they are fed in, whereby turbulence forms in the water/air/pipe wall boundary areas. The intermittent flow velocities of the water blocks induce an extremely intense drag stress. The turbulence at the phase boundaries between the water and air blocks also causes controlled cavitation. Water distribution networks can thus be efficiently cleaned of biofilms and deposits (Fig. 2).

Figure 2: Discharge of deposits during the pulse flushing process

As the water only flows laminar into the pipe section to be cleaned at low flow velocities, neither pressure reduction nor turbidity affect the drinking water supply in the rest of the pipe network.

New developments, which were possible as part of research projects [6] at a test facility, increase the effectiveness of the process. A prerequisite for the tests is a verification procedure for the effectiveness of the cleaning process. The adhesion of the deposits and the shear forces required to remove them can thus be easily checked. Based on this, the cleaning parameters can be optimized. These innovations, coupled with pioneering research at universities, open up new perspectives for the use of the Comprex pulse rinsing process. For example, the densities of metazoans in a pipe network with heavy biofilm infestation were determined and the effectiveness of biofilm reduction by cleaning with the Comprex pulse flushing process on the metazoan infestation was investigated [8]. Such cooperation leads to new ways of ensuring water quality.

The quality of the water in the pipe networks through scientific support, especially with regard to the expected effects of climate change on drinking water distribution networks.

4 Experience through climate change

In parallel to climate change, demographic developments are having an impact on water supply [9]. Population decline and the associated fall in drinking water consumption mean longer retention times and stagnation, which can ultimately affect water quality (see Table 1).

Drinking water distribution network				
New boundary conditions	Climate change	Reduced installation depth	Demographic change	Reduced water consumption
New operating conditions conditions	Increased water temperature		Extended dwell times	
Impairment of the pipe network	Accelerated formation of deposits and biofilms			
	More culture media for animals, altered fauna			
Measures	Repair by basic cleaning: Restore the condition as it was during planning and construction			
	Maintenance through regular inspection and maintenance cleaning; maintenance of the restored condition, documentation			

Table 1: Measures in the event of changed boundary conditions and their consequences

Both causes pose new challenges for cleaning. Prompted by increased values for microbiological parameters or indicator parameters, quick solutions are required. Just as important as these immediate measures is the far-sighted planning of cleaning measures so that such impairments do not occur in the first place. This is because, depending on the type of pipe, type of water and operating conditions, biofilms can form in drinking water distribution networks over the years in addition to deposits. Deposits increase the nesting potential for microorganisms. Biofilms can be a food source for higher animals. Cleaning measures are based on updated inventory plans. Based on this, cleaning measures can often be planned in combination with valve inspections and valve upgrades. The combination of pipe network cleaning and condition-oriented valve maintenance shows interesting synergy effects [10]. For example, the costs for pipe network cleaning can be offset by extending the service life of the refurbished valves. Further potential savings can be made by cleverly distributing the work between the service provider and the pipe network operator.

Service providers for cleaning pipe networks, raw water and wastewater pressure pipes and drinking water installations are seeing trends that can be attributed to climate change as well as demographic developments and new installation situations for pipelines. Efficient methods for removing deposits, biofilm and animals from pipes are becoming increasingly important. It is important to plan the measures carefully and then document them.

5 Summary

The pulse flushing process not only removes deposits and biofilms, but also animals from drinking water pipes. Collaborations, including research projects, lead to new findings and further developments of the cleaning process. The removal of deposits minimizes the potential for microorganisms to settle. The removal of the biofilm in turn reduces the food source for animals. The aim of the cleaning measure is to restore contaminated drinking water distribution networks to a hygienically wall-free condition. Studies by the cooperation partners confirm the effectiveness of the pulse flushing process. This is an important prerequisite for maintaining pipelines that have been affected by climate change in particular.

6 Literature

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