WATER RESEARCH 45 (2011) 3215–3224

Available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/watres

ELSEVIER

WATER RESEARCH

Distribution of *Asellus aquaticus* and microinvertebrates in a non-chlorinated drinking water supply system – Effects of pipe material and sedimentation

Sarah C.B. Christensen [a,*], Erling Nissen [b], Erik Arvin [a], Hans-Jørgen Albrechtsen [a]

[a] *DTU Environment, Technical University of Denmark, Bygningstorvet B115, 2800 Kgs. Lyngby, Denmark*
[b] *VCS Denmark, Vandværksvej 7, 5000 Odense C., Denmark*

ARTICLE INFO

Article history:
Received 3 October 2010
Received in revised form
10 March 2011
Accepted 21 March 2011
Available online 29 March 2011

Keywords:
Invertebrates
Microbial quality
Distribution system
Cast iron
Water storage tank

ABSTRACT

Danish drinking water supplies based on ground water without chlorination were investigated for the presence of the water louse, *Asellus aquaticus*, microinvertebrates (<2 mm) and annelida. In total, 52 water samples were collected from fire hydrants at 31 locations, and two elevated tanks (6000 and 36,000 m^3) as well as one clean water tank at a waterworks (700 m^3) were inspected. Several types of invertebrates from the phyla: arthropoda, annelida (worms), plathyhelminthes (flatworms) and mollusca (snails) were found. Invertebrates were found at 94% of the sampling sites in the piped system with *A. aquaticus* present at 55% of the sampling sites. Populations of *A. aquaticus* were present in the two investigated elevated tanks but not in the clean water tank at a waterworks. Both adult and juvenile *A. aquaticus* (length of 2–10 mm) were found in tanks as well as in pipes. *A. aquaticus* was found only in samples collected from two of seven investigated distribution zones (zone 1 and 2), each supplied directly by one of the two investigated elevated tanks containing *A. aquaticus*. Microinvertebrates were distributed throughout all zones. The distribution pattern of *A. aquaticus* had not changed considerably over 20 years when compared to data from samples collected in 1988–89. Centrifugal pumps have separated the distribution zones during the whole period and may have functioned as physical barriers in the distribution systems, preventing large invertebrates such as *A. aquaticus* to pass alive. Another factor characterising zone 1 and 2 was the presence of cast iron pipes. The frequency of *A. aquaticus* was significantly higher in cast iron pipes than in plastic pipes. *A. aquaticus* caught from plastic pipes were mainly single living specimens or dead specimens, which may have been transported passively trough by the water flow, while cast iron pipes provided an environment suitable for relatively large populations of *A. aquaticus*. Sediment volume for each sample was measured and our study described for the first time a clear connection between sediment volume and living *A. aquaticus* since living *A. aquaticus* were nearly only found in samples with sediment contents higher than 100 ml/m^3 sample. Presence of *A. aquaticus* was not correlated to turbidity of the water. Measurements by ATP, heterotrophic plate counting and Colilert® showed that the microbial quality of the water was high at all locations with or without animals. Four other large Danish drinking water supplies were additionally sampled (nine pipe samples and one elevated tank), and invertebrates were found in all systems, three of four containing *A. aquaticus*, indicating a nationwide occurrence.

© 2011 Elsevier Ltd. All rights reserved.

* *Corresponding author*. Tel.: +45 45251600; fax: +45 932850.
E-mail address: scch@env.dtu.dk (S.C.B. Christensen).

0043-1354/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.watres.2011.03.039

1. Introduction

Invertebrate animals are present in drinking water distribution systems worldwide. In tropical and subtropical countries, some species of invertebrates can act as secondary hosts for parasites and thereby pose a serious health risk to consumers (Evins, 2004). In temperate areas, the presence of the animals is largely regarded as an aesthetic problem (van Lieverloo et al., 2002). However, previous studies have shown that invertebrates such as crustaceans and nematodes can harbour bacterial pathogens and potential pathogens e.g. *Escherichia coli* (indicator organism for faecal contamination) (Bichai et al., 2009; Levy et al., 1984), *Salmonella wichita* (Smerda et al., 1971) and *Campylobacter jejuni* (Schallenberg et al., 2005) and may play a role in the survival of these organisms in drinking water systems. The Danish water supply systems are based on ground water without chlorination, which may increase the risks of growth of bacteria and biofilm formation in the water pipes (Martiny et al., 2003) that may serve as a food supply for animals in the system. The absence of hygienic barriers between waterworks and consumers in terms of chlorination increases the focus on any potential carrier of pathogens such as e.g. invertebrates.

The abundance of invertebrates in distributed drinking water is a source of consumer complaints and the supply companies highly desire to control the invertebrate abundance. Well established sampling methods have been developed in the Netherlands to assess the abundance of most invertebrate taxa in distribution systems, and a two-year survey has confirmed the wide abundance of invertebrates (van Lieverloo et al., 2004). However, studies on the controlling parameters for the distribution of invertebrates on full scale distribution systems are still lacking. In order to obtain and distribute biostable drinking water, biostable materials are needed. van der Kooij et al. (1999), and van Lieverloo et al. (2002) therefore suggested that pipe material may influence the occurrence of invertebrates. This hypothesis has not been tested on a full scale distribution system, nor has the correlation to sedimentation in the pipes and turbidity of the water. van Lieverloo et al. (2002) suggest that multiplication of invertebrates in distribution systems depends on the presence of biofilms and sediment and it is known that keeping the pipes clean by e.g. flushing reduces the amount of invertebrates in the system (Levy, 1990; van Lieverloo et al., 1998). The risk of high sedimentation rates may be enhanced in water pipes constructed for higher flows than the actual flow due to e.g. reduction of water consumption.

The water louse, *Asellus aquaticus*, is present in water distribution systems globally (Australian Government, 2004; Gauthier et al., 1999; Gray, 1999), which often causes consumer complaints (Walker, 1983 and unpublished results) due to its size, which makes it visible to the naked eye. Another nuisance is discolouration of the water by the faeces (pellets) of *A. aquaticus*. A survey from the Netherlands showed that though *A. aquaticus* was not the most abundant of invertebrates present in water distribution systems, most of the invertebrate biomass (86%) was formed by *A. aquaticus* (van Lieverloo et al., 1998).

The aims of this study were, a) to implement methods to examine the distribution of invertebrates in a drinking water system with special emphasis on *A. aquaticus*, b) to investigate the spatial distribution of *A. aquaticus* in different pressure zones and c) to identify factors influencing or being influenced by the presence of *A. aquaticus* with special emphasis on pipe materials, sedimentation, turbidity and microbial water quality.

2. Material and methods

2.1. Locations

The investigated water supply system, VCS Denmark, in Odense, Denmark supplies approximately 150,000 people via a distribution system with 1000 km of pipes and a total pipe volume of 40,000 m^3. The supply company distributes about 10 million m^3 per year with an average flow velocity in the pipes of 0–0.5 m/s. Hence the average residence time is two days but varies from 1 to 14 days. The majority of the pipes are of PVC (polyvinyl chloride) (46%) or PE (polyethylene) (33%), while 20% of the pipes are concrete, asbestos cement or ductile iron pipes (Table 1). The remaining cast iron pipes (1%) are currently being replaced by plastic pipes. The supply system is divided into eleven pressure zones of which seven zones were sampled (Table 1). Although connected, the pressure varies between the different zones, which are separated by centrifugal pumps. The supply network is constructed after a finger principle, which means that it is branched and has a unidirectional flow, hence terminating at the consumers. The transmission network on the other hand is designed as a ring system in order to obtain security of supply. The raw

Table 1 – Characteristics and number of sampling sites in the various distribution zones.

Zone	Area [km^2]	Pipes [km]	Resident population #	Revenue water [m^3]	Pipe material [%]			Samples taken #	
					Plastic	Cast iron	Other	Plastic	Cast iron
1	78	463	93,567	5,971,911	74	2	24	11	8
2	78	383	54,467	2,871,174	81	1	18	5	2
3	23	43	1624	83,474	99	0	1	1	0
5	16	22	1557	79,535	96	0	4	1	0
6	7	8	281	11,040	93	0	7	1	0
7	4	12	1805	84,525	100	0	0	1	0
8	2	5	208	9616	100	0	0	1	0
Total	208	936	153,509	9,111,275	79.2	1.4	19.4	21	10

Download English Version:

https://daneshyari.com/en/article/4483252

Download Persian Version:

https://daneshyari.com/article/4483252

Daneshyari.com