Finnish tap water microbiological quality in remote network ends and under network maintenance.

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INTRODUCTION

- In Finland, controlled measurement program based on WHO recommendations and followed by water utilities and authorities guarantees excellent tap water quality.
- Remote branches with potentially lower water consumption, however, may not be efficiently covered by the program using culture-based microbiological methods.
- Another potential risk point are maintenance works.
- This poster represents joint work of TeVe Water and 16 Finnish water utilities from two projects VÄRINÄ in 2021 and VERLA in 2019-2020 using culture-independent microbiological methods to assess water quality in remote ends and under maintenance works. .
- Work continues in VÄRISE project in 2022-2023.

RESULTS AND DISCUSSION

- Potable water networks disinfected with monochloramine (NH_2Cl, Fig.1a) typically showed higher proportion of proteobacteria and lower proportion of other phyla than networks disinfected with sodium hypochlorite (NaClO, Fig. 1b) and especially networks not using chlorine in disinfection (No Cl, Fig. 1c)

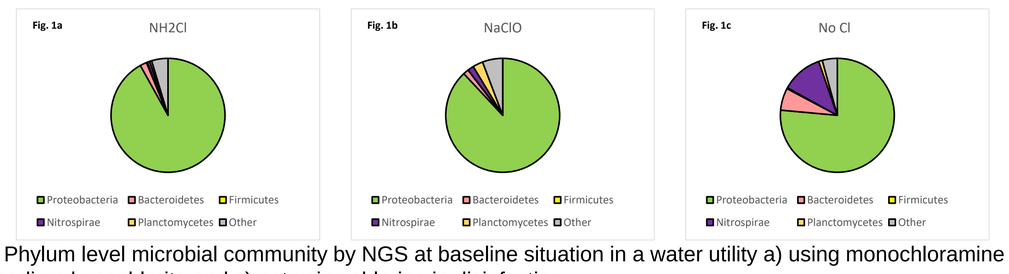

Fig. 1. Phylum level microbial community by NGS at baseline situation in a water utility a) using monochloramine b) using sodium hypochlorite and c) not using chlorine in disinfection.

- Total chlorine decreased rapidly after the water left the plant (Fig. 2a)
- Microbial levels increased towards the remote ends (Fig. 2b), but the relationship to chlorine or any other background variable was not straightforward.
- Higher ATP levels were on average observed in August-September and especially October than in June-July (Fig. 2b) probably due to increasing soil temperatures towards the autumn

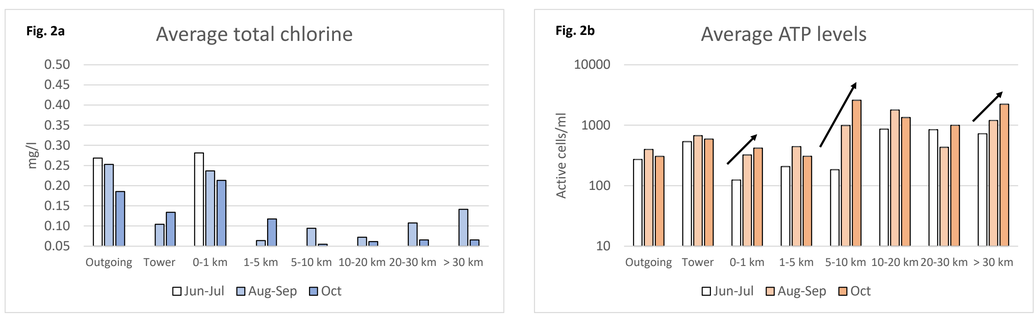

Fig. 2. a) Total chlorine and ATP averages calculated from individual water utility data for the different distances from disinfection points from plants using monochloramine separately for June-July, August-September and October 2021.

- Overall, the total community structure was proven stable in relation to major clusters even in remote ends (Fig. 3a)
- Certain bacteria, such as legionella, were nevertheless proven more sensible for chlorine treatment than other bacteria (Fig. 3b)

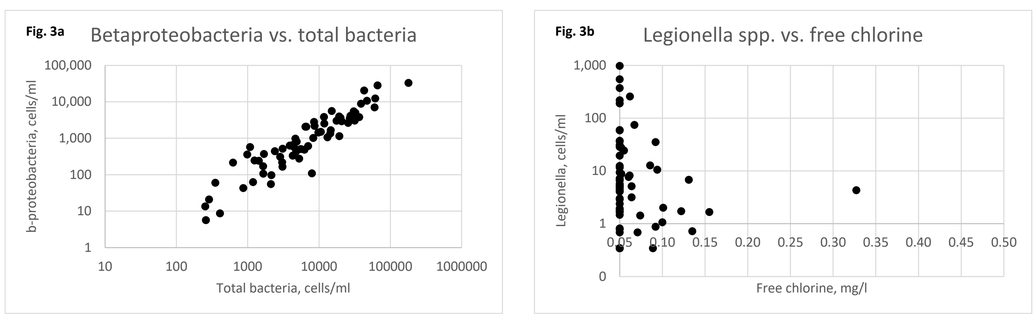

Fig. 3. a) β-proteobacteria versus total bacteria measured by qPCR b) Genus *Legionell*a measured by qPCR versus free chlorine levels measured spectrophotometrically on-site (with detection limit of 0.05 mg/l).

RESULTS AND DISCUSSION

- Indices calculated from the qPCR data remained at the background level more often when monochloramine was used in disinfection than with usage of sodium hypochlorite or no chlorine chemical (Table 1).
- Maintenance contributed to the detachment of biofilms in certain sampling points and resulted in slightly elevated risk during and directly after the maintenance work while the microbiological status was normalized after 2 months (Fig. 4a).
- Condition of the network and the delay in water transport and consumption also affected microbial quality (Fig. 4b)

	Monochloramine			Sodiumhypochlorite			No chlorination		
Microbial quality	At background level	Elevated biofilm index	Elevated bacterial index	At background level	Elevated biofilm index	Elevated bacterial index	At background level	Elevated biofilm index	Elevated bacterial index
Before	18/20 90%	2/20 10%	2/20 10%	6/10 60%	3/10 30%	4/10 40%	2/6 33%	4/6 67%	4/6 67%
During	6/7 86%	1/7 14%	1/7 14%	2/5 40%	2/5 40%	2/5 40%	3/17 18%	9/17 53%	12/17 71%
≤1 mo after	9/10 90%	1/10 10%	1/10 10%	6/6 100%	0/6 0%	0/6 0%	2/6 33%	3/6 50%	4/6 67%
>1 mo after	10/10 100%	0/10 0%	0/10 0%	2/4 50%	0/4 0%	2/4 50%	4/4 100%	0/4 0%	0/4 0%

Table 1. Indices calculated from qPCR data as compared to background levels before, during, less than one month after and more than one month after the completion of the maintenance work.

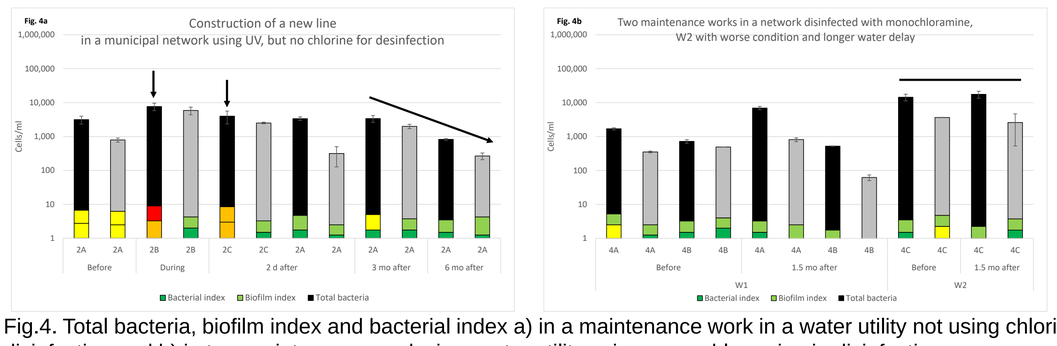

Fig.4. Total bacteria, biofilm index and bacterial index a) in a maintenance work in a water utility not using chlorine in disinfection and b) in two maintenance works in a water utility using monochloramine in disinfection.

SAMPLES AND METHODS

In VÄRINÄ project in summer-autumn 2021, water samples were collected from potable water networks of 11 water utilities from

- 1-4 outgoing waters leaving a water plant or a disinfection point
- 2-9 remote ends of the network

7 networks were sampled once and 4 multiple times during summer-autumn 2021.

In VERLA project in 2019-2020, water samples were collected from potable water networks of 11 water utilities from the site of a maintenance work

- Before the start of a maintenance work
- During the maintenance work
- After the maintenance work

to obtain a time series at intervals depending on the duration and extent of the work.

Culture independent microbial methods were used to verify the microbiological quality

- Adenosine TriPhosphate (ATP), a measurement based on cell energy metabolism
- Quantitave Polymerase Chain Reaction (qPCR) and Next-Generation-Sequencing (NGS) based on microbial DNA

CONCLUSIONS

- Especially ATP, but also other culture-independent methods, was proven as a quick and relevant tool for routine monitoring of potable network water quality.
- Results from VERLA ja VÄRINÄ projects emphasized use, type and dosage of disinfection chemicals used at the water plant and in the network. Monochloramine retained disinfection capacity better than sodium hypochlorite. Overall, chlorine levels decreased rapidly when the water left the plant.
- Microbial activity increased towards remote ends with complex relationship to chlorine and other background variables.
- Higher soil temperatures most likely contributed to increased microbial activity in the network towards autumn.
- Maintenance contributed to detachment of biofilms and resulted in slightly elevated risk during and directly after the work, but the status normalized in 2 months.

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