The virtual conference of AQUA≈360: Water for All - Emerging Issues and Innovations

31st August 2021 – 2nd September 2021, University of Exeter, United Kingdom

Trialling a community scale decentralised point-of-use drinking water treatment system

Clayton, G E.[1]*, Fox, B. F.[1], Thorn, R. M. S.[1] and Reynolds, D. M[1]
[1] Centre for Research in Biosciences, University of the West of England, Bristol, UK, BS16 1QY
[1]*gillian.clayton@uwe.ac.uk*

Keywords: Biologically safe drinking water, Community Scale, Decentralised water treatment, Hypochlorous acid

EXTENDED ABSTRACT

Introduction

The effective disinfection of drinking water is essential if biologically safe drinking water, throughout distribution networks, is to be available. However, where large scale treatment systems and distribution networks are unrealistic due to financial constraints or resource availability, community scale decentralised treatment systems provide an alternative solution. Decentralised drinking water treatment systems can negate the need for distribution networks as they are intended for point-of-use [POU] drinking water consumption. Traditional chlorine solutions (e.g. sodium hypochlorite, NaOCl) that maintain disinfection throughout drinking water distribution networks, need to be replaced by alternative disinfection technologies that show are promise for application in remote locations where the lack of access to safe drinking water and resources is the most acute. Such alternative disinfection technologies include electrochemically generated hypochlorous acid (HOCl), that have proven to be efficacious as well as minimising the formation of disinfection by-products, such as trihalomethanes [2]. Furthermore, such disinfectants can be produced on demand and in-situ and such innovations could help the 30% of global population who not have access to safely managed drinking water sources. The overall aim of this study is to test a developed decentralised drinking water treatment system over an 11-week period with two flow rates: 0.3m^3/hour and 0.5 m^3/hour. The biological, chemical, metallic and physicochemical water quality parameters were assessed against UK drinking water standards [3].

Methods and Materials

A proof-of-concept decentralised drinking water production system that was previously tesed by the authors [1], combines multi-step filtration and disinfection processes. This system has been further developed to increase the volume of treated water produced (PAQUA 1000D-2), see Figure 1. Raw water from an artificial water body (an urban drainage holding pond, UWE Bristol) was drawn into two 1000L intermediate bulk containers [IBC] before passing through a 5 µm prefilter-ionisers (PolletWater Group, Belgium) into a 1000L header IBC tank. Prefiltered water was then passed through a 50µm filter, and dosed with HOCl generated from an ELA-900 generator (more information below), to a maximum free chlorine concentration of 2.0 mg/L. Disinfected water then entered the ultrafiltration [UF] membranes with a pore size of 0.02µm (Dizzer 4040-4.0 Inge, Lenntech, The Netherlands) before being stored in a 1000L treated water IBC tank.

Figure 1. The decentralised drinking water treatment system (PAQUA 1000-D) trialled at the University of the West of England, Bristol.

Hypochlorous acid (pH of 5.65 ± 0.15) was generated through the electrolysis of a 1% saline solution with an ELA-900 generator (Envirolyte, Estonia). The free chlorine concentration of HOCl produced was 365 ± 15 mg/L, resulting in an oxidation reduction potential of 800 ± 15 mV.

Water analysis was undertaken on the raw water source, the header tank and the treated water tank. Samples were collected in sterile vessels provided by Wessex Water Scientific Laboratories, an ISO 17025 accredited laboratory. All water samples were analysed for biological, chemical, metallic and physicochemical quality against UK drinking water standards.

A telemetry system collated 5-minute rolling averages of the following operational parameters; flow rate of incoming raw water source, differential pressure across the membranes, oxidation reduction potential and free chlorine in real time.

Results and Discussion

The biological quality of the raw water source and the header tanks, exceeded permissible levels throughout the trial, as *Clostridium perfringens*, coliforms, *Enterococci* and *Escherichia coli* were present in all samples. In contrast, all treated water samples reached permissible drinking water limits, demonstrating the ability to produce biologically safe water using the described system. The chemical parameters tested throughout this trial (ammonia, chloride, nitrate, nitrite, orthophosphate, silica and sulphate) met UK drinking water standards in all samples (pre and post treatment) taken from each sampling location. The values for pH, conductivity, colour, total hardness, non-carbonate hardness, alkalinity and total organic carbon also fell within acceptable drinking water quality levels for raw water, header tank and treated water samples. Turbidity values for header and treated water were deemed acceptable although, for raw water samples turbidity exceeded the prescribed threshold (> 4 NTU). The metallic parameters tested from the header and treated water tanks throughout this trial (specifically, aluminium, calcium, iron, lead, manganese, magnesium, potassium, sodium and zinc) met UK drinking water standards. There was a significant reduction ($p < 0.05$) in aluminium and iron concentrations between the raw water source and the header and treated water tanks, bringing the treated water in line with UK drinking water standards.

There was no difference in treated water quality at either of the flow rates tested throughout the trial (0.3m^3/hour and 0.5 m^3/hour), demonstrating that automatic disinfectant dosing can produce high quality drinking water, whilst maximising treated water output. However, increasing the flow rate did affect the operational function of the system. Transmembrane pressure across UF membranes increased, requiring UF membranes to undergo automatic enhanced cleaning (soaking UF membranes for 30 minutes in HOCl solution). This ensures transmembrane pressure remained within operational thresholds (< 0.64 bar.), but this does result in zero production of drinking water whilst the cleaning cycle takes place.

Conclusions

An 11-week field trial investigated the quality of treated water from a decentralised drinking water treatment system when two flow rates were tested. All treated water samples met UK drinking water standards, demonstrating the system's capability to consistently produce high quality drinking water. None of the untreated samples **(**raw and header tanks**)** met UK drinking water standards, due to the presence of biological parameters. Further trials**,** are required to optimise the flow rate, ensuring a maximum production of drinking water, whilst minimising periods where no drinking water is produced. Additional trials should be carried out to ensure the system is capable of continuously running under different environmental conditions, such as increased temperature and humidity. There is great potential and need for decentralised drinking water treatment systems.

Acknowledgements

This study was funded by the Natural Environment Research Council, UK [NE/R003106/1]. The authors would like to thank Portsmouth Aviation Ltd for designing and building the PAQUA 1000D-2 unit.

REFERENCES

[1] Clayton, G. E., Thorn, R. M. S., and Reynolds, D. M. 'Development of a novel off-grid drinking water production system integrating electrochemically activated solutions and ultrafiltration membranes'. Journal of Water Process Engineering, Vol 30. 2019. doi: 10.1016/j.jwpe.2017.08.018

[2] Clayton, G. E., Thorn, R. M. S., and Reynolds, D. M. 'Comparison of Trihalomethane Formation Using Chlorine-Based Disinfectants Within a Model System; Applications Within Point-of-Use Drinking Water Treatment'. *Frontiers in Environmental Science*. Vol 7. 2019 doi: 10.3389/fenvs.2019.00035

[3] Drinking Water Inspectorate. Guidance on the implementation of the water supply (water quality) regulations 2000 (as amended) in England. Drinking Water Inspectorate London: Drinking Water Inspectorate; 2012