SafeCREW GUIDELINE #1

APPLICATION GUIDELINE ABOUT DISINFECTION BY-PRODUCT PRECURSOR REMOVAL BY DIFFERENT MATERIALS

Figure 1 Adsorption of Natural Organic Matter (NOM) to minimize Disinfection By-Products (DBPs) by means of conventional and new advanced adsorbent materials

Introduction

Water disinfection by common disinfectants is a crucial step in ensuring safe drinking water by removing pathogenic bacteria. However, the reaction of such chemicals with natural organic matter (NOM) present in water may generate disinfection by-products (DBPs). One approach to prevent this undesired production is the removal of NOM by adsorption prior to the disinfection process. Among conventional adsorbents, activated carbon (AC) have been widely studied. Nevertheless, there is not a one-for-all solution, and operative conditions need to be investigated for specific treatments. Moreover, the design of new advanced adsorbent materials is encouraged to provide more sustainable and efficient solutions. This guideline presents a summary of Deliverable D2.3, which shall enable the evaluation of conventional adsorbents (i.e. AC) and innovative adsorbents, made of cellulose nanofibers cross-linked to form cellulose nanosponges (CNS), to enhance water treatment processes before disinfection, also providing guidelines for those drinking water treatment plants (DWTPs) which might not have experience with the selection of adsorbents.

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Target Audience

The guideline targets water utilities, adsorbent materials producers and decision makers and shall pave the way for the adoption of advanced water treatment solutions to ensure safe drinking water in a climate change scenario.

Scope and Objectives

This document summarizes the set of guidelines presented in D2.3 "Application guideline about disinfection-by-product precursor removal by different materials". It is designed to help in the identification, selection and design of the most effective adsorbents (both AC and innovative adsorbent materials) and operational configurations to prevent DBPs formation by NOM removal. As the output strictly depends on the origin of water and of the NOM to be retained, four different scenarios were considered and tested in three different case studies.

I. Conversion from non-disinfected to disinfected drinking water supply (CS1B, tested by UBA);

II. Upgrade of currently disinfected systems targeting precursors removal (CS3T, tested by CAT);

III. Development of innovative adsorbent materials (CS2M, tested by POLIMI);

IV. Proposal of new treatment line scheme with pre-chlorination followed by adsorption (tested by EUT).

Guidelines for adsorbent materials selection in several scenarios

1) Conversion from non-disinfected to disinfected drinking water supply

In Germany and the Netherlands most DWTPs currently do not need to apply disinfection in their water treatment procedures. This might change with the impacts of climate change and DWTPs need to adapt their treatment processes.

This guideline provides a procedure to evaluate a potential future combination of adsorption and disinfection for safe drinking water production.

Steps contain: a) selection of commercially available activated carbons with varying characteristics; b) water pre-treatment for NOM removal by selected AC; c) chlorination of untreated and pre-treated water and detection of changes in DBPs formations (see steps 1- 3 in Figure 2).

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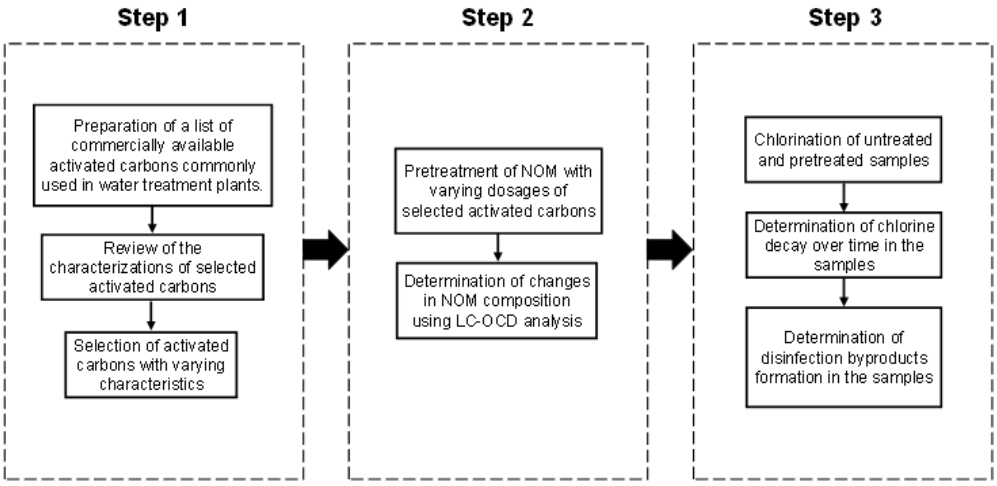

Figure 2 Experimental flow chart for evaluating activated carbon pre-treatment effects.

2) Upgrade of currently disinfected systems targeting precursors removal

Many European DWTPs already have a disinfection step in place. However, the need to reduce DBP formation has only recently emerged. These DWTPs need a procedure to select those adsorbents which achieve optimal removal of DBP precursors.

Steps contain a) NOM characterization for the feed water matrices collected in different times of the year to find which part of the NOM is mainly responsible for DBPs formation according to the workflow reported in Figure 3; b) selection of granular activated carbon (GAC) to determine the best performing ones in removal of target NOM according to workflow depicted in Figure 4.

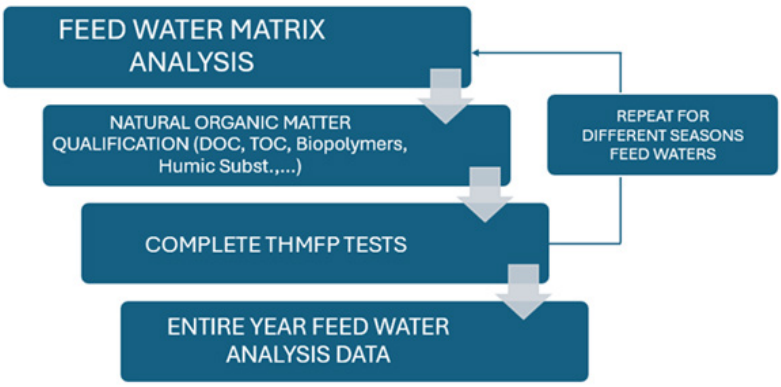

Figure 3 Workflow for NOM characterization.

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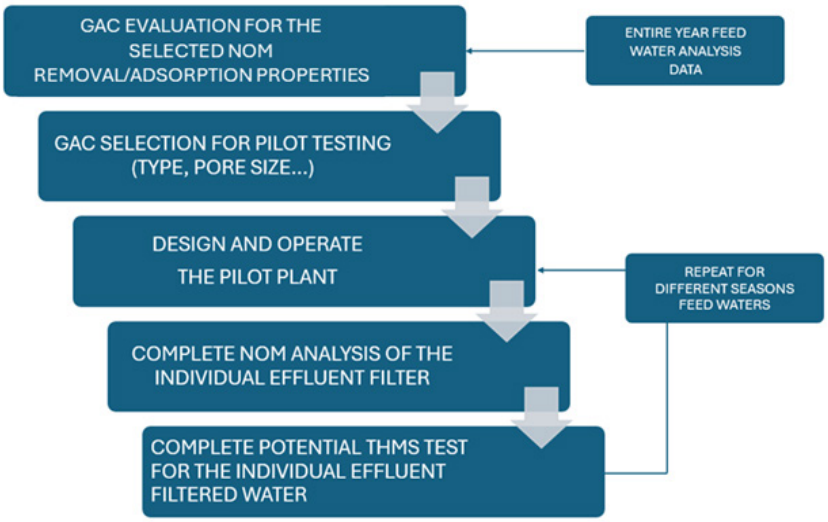

Figure 4 Workflow on laboratory tests and data analysis for GAC evaluation.

Figure 5 shows the pilot plant used to perform experiments, together with a description of main operating parameters.

Diameter	5,4	cm
Height	54	cm
Filter Bed Height	30	cm
Maximum flow	11	L/h
Minim flow	4	L/h

Figure 5 Pilot plant activated carbon columns and description of main operating parameters.

3) Development of innovative adsorbent materials

Conventional GAC have several disadvantages, e.g. a lack of efficiency towards small and/or polar organic molecules, sustainability or cost effectiveness. The development of new adsorbents may possibly overcome these disadvantages. This guideline presents a procedure for the development and optimization of a specific adsorbent material and the comparison with benchmark activated carbons (Figure 6).

Steps contain a) the design and development of cellulose-based nanosponges (CNS) as unconventional adsorbents (Figure 6); b) their chemical and morphological characterization; c) laboratory tests to evaluate the efficiency in NOM removal compared to selected AC; d) the correlation between the DBP formation and the adsorbent material used for NOM removal.

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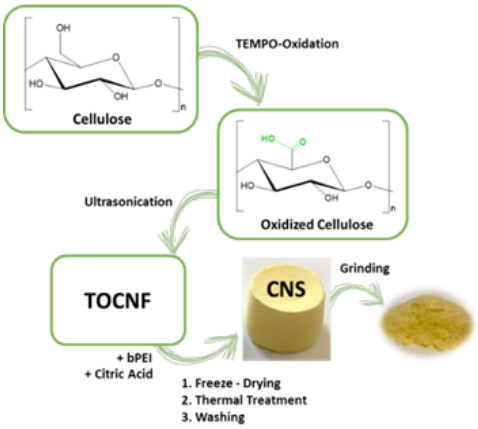

Figure 6 Experimental steps for the synthesis of CNS.

4) Proposal of new treatment line scheme with pre-chlorination followed by adsorption

If new drinking water treatment plants need to be built, with the need of high dosing of disinfectants, new treatment lines might be necessary. This guideline outlines the steps towards the selection and development.

Steps contain a) pre-chlorination; b) adsorption; c) evaluation of the effect of water chlorination on GAC adsorption (Figure 7).

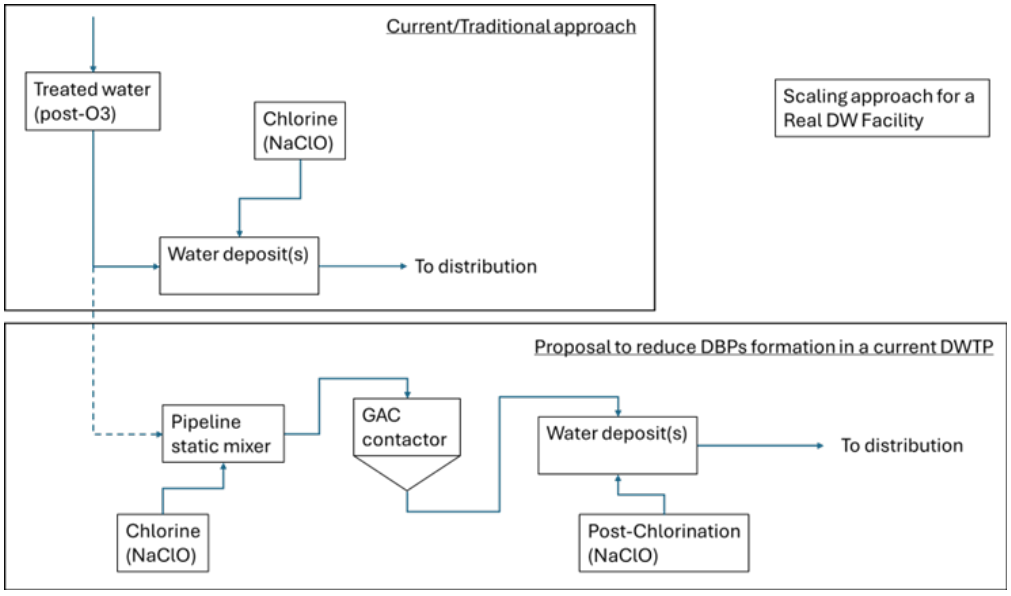

Figure 7 Workflow for assessing the effect of pre-chlorination on adsorption performance.

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Conclusion

Procedures following the guidelines above were tested and evaluated in the SafeCREW case study sites in Berlin, Milan and Tarragona. The guidelines proved useful and the results of the testing are described in Deliverable D2.3 Application guideline about disinfection-by-product precursor removal by different materials. Also, more details about the guidelines are described in this deliverable.

References

- Stefanoni, M., Riva, L., Punta, C., Fargas Marques, A., Fabregas Serra, J., Martorell, A., Jubany Güell, I., Pérez Estrada, L., Vinardell Magre, L., Ruhl, A.S. and Ranjbar, E., 2024. SafeCREW Deliverable D2.3 Application guideline about disinfection-by-product precursor removal by different materials, submitted to EC by 30 October 2024.

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