



Evaluation of an innovative online system for bacterial total activity determination in process and drinking water



La gestió responsable



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INTRODUCTION

Nowadays, microbiological water safety is rising as one of the major concerns regarding production and distribution of drinking water. The current microbial water quality monitoring techniques are still time-consuming and mainly restricted to culturable bacteria. Therefore, the development of rapid and accurate microbiology monitoring systems is a key factor to enable drinking water supply systems to ensure safe water for the population. In the frame of Aquavalens project (7th Framework Programme, EU) innovative and advanced detection methods for microbial water monitoring have been explored. BACTcontrol, one of these improved tools, can help to gain a better understanding of the living microorganisms found in drinking water and to evaluate the effectiveness of processes in drinking water treatment plants (DWTP) and distribution.

METHODS

BACTcontrol (microLAN) is a fully automated online system detecting the presence of bacterial activity in water. It is based on an enzymatic reaction that makes the bacteria visible for fluorescence detection and thus can be used for detection of *E.coli*, coliforms or bacterial **Total Activity (TA)** in water. This last parameter has been tested for first time within **Aquavalens** project with process waters from Sant Joan Despi, the main DWTP in **Barcelona**.



Figure 1 – BACTcontrol system at Barcelona site

This plant, which is managed by **Aigües de Barcelona**, is a very suitable scenario for at-site sensors evaluation because of its complete treatment scheme (Figure 2). Treatment processes selected for BACTcontrol's online verification were **sand filtration**, **ozonation**, **granular active carbon (GAC) filtration** and **post-chlorination** (drinking water). The system ran from March to December 2017, being the days distribution indicated in Figure 2 (orange boxes).

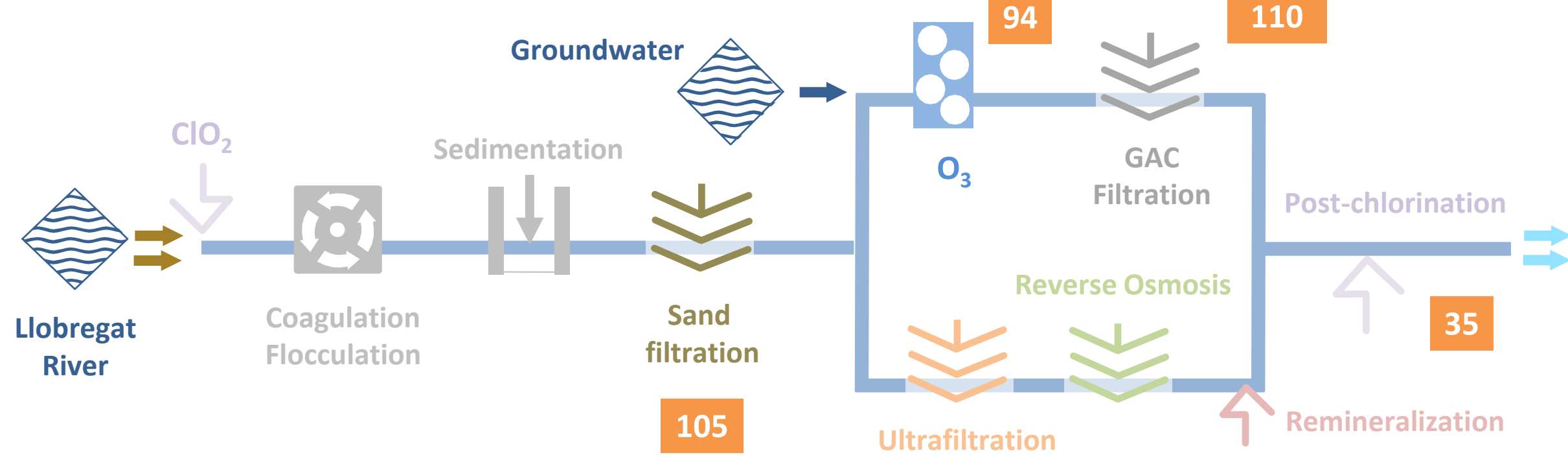


Figure 2 – Sant Joan Despi DWTP treatment scheme and days of BACTcontrol's evaluation per process

Due to the innovative nature of TA parameter, the evaluation plan had two objectives:

1. Understanding the new information that the device is providing
2. Determining how DWTP operators can use these data for process control and optimization procedures

To do so, the strategy included comparison of TA values with:

- **Microbiological parameters:** Heterotrophic Plate Count at 22°C (Water ISO Plate Count Agar, 72h at 22°C, ISO 6222 (1999) [1]); ATP viability assay using reagent Bacter-Glo™ (Promega, USA) and complementary microscopy based techniques for Total Cell Count (TCC) by DAPI staining and for Viable Cell Count by EUB-FISH (Fluorescence In Situ Hybridisation) probe.
- **Physicochemical parameters:** temperature, TOC, UV254, turbidity, particle count, conductivity and pH (online data).
- **Operational parameters:** % of groundwater treated, ozone dose and filter backwash schedules.

RESULTS AND DISCUSSION (2)

TA reflects bacterial dynamics during the treatment process, showing mainly decreases after disinfection and increases after filtration beds.

- Highly chlorinated waters always showed TA values close to zero and partial ozonation lead to intermediate values.
- High microbiological activity was detected in GAC filters: TA confirmed and followed up **bacterial growth in active carbon beds** after ozone disinfection.

Moreover, a confirmed surface **water quality event** affecting several stages of the DWTP was early detected after **sand filtration** with BACTcontrol TA (Figure 4).

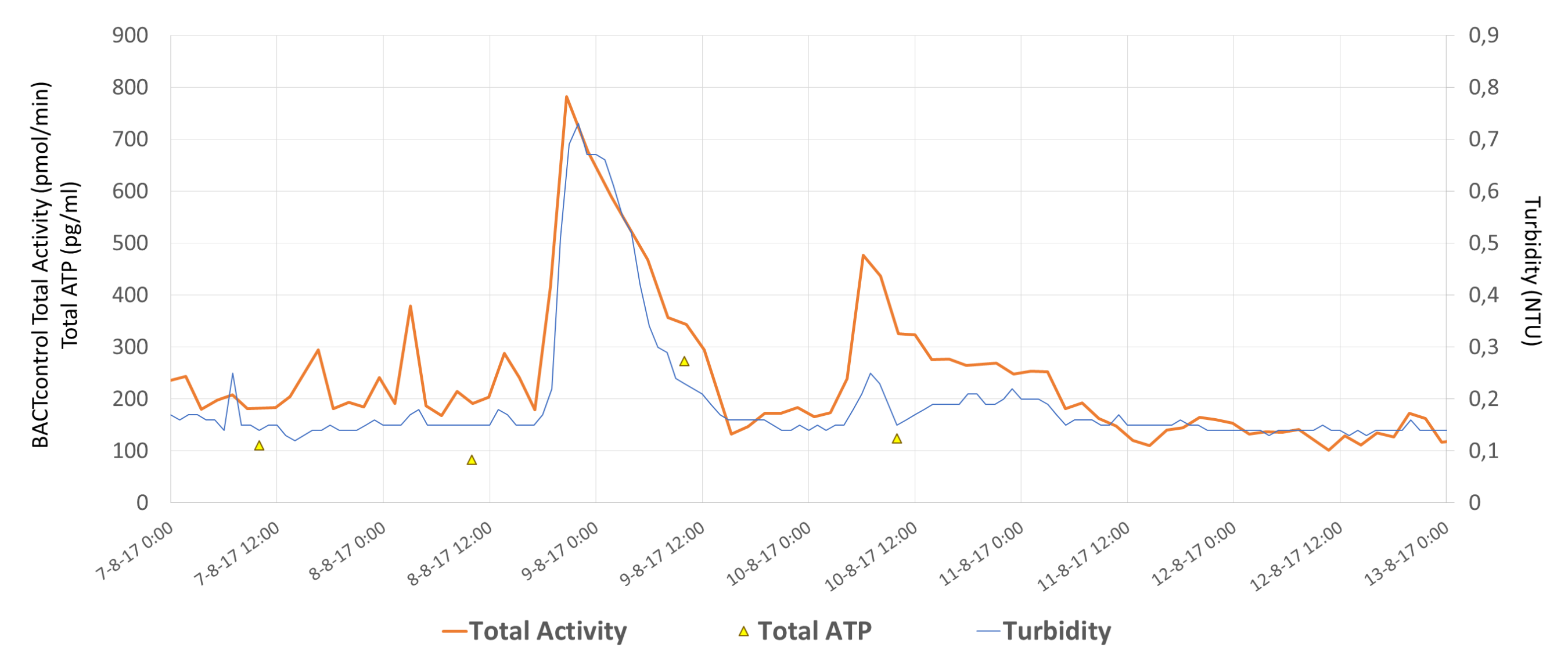


Figure 4 – TA and turbidity follow-up after sand filtration during a quality event coming from river water

During a rainfall episode, untreated wastewater coming from combined sewer overflows reached the Llobregat River and was pumped into the DWTP pretreatment. This phenomenon involves increases in organic and particulate matter and pathogens presence. So far, online turbidity has been the main event indicator in sand filtration. As seen in Figure 4, BACTcontrol TA is quite more sensitive than turbidity to the presence of polluted water, as well as more representative since it refers only to living bacteria.

Therefore BACTcontrol TA can contribute to ISO 22000 implementation, since improved microbial risk assessment could be achieved by a better monitoring of critical control points in treatment process such as sand filtration.

Finally, as it can be seen in Table 1, a comparison between TA and other global indicators by calculating correlation coefficients was carried out:

Table 1 – Correlation matrix (r) for Total Activity and routine microbiological indicators

GAC filter					Sand filter				
	Total Activity	Total ATP	HPC 3 days	HPC 7 days		Total Activity	Total ATP	HPC 3 days	HPC 7 days
n	36	64	30	30	n	41	46	22	22
Total Activity	1				Total Activity	1			
Total ATP	0,097	1			Total ATP	0,464	1		
HPC 3 days	-0,066	0,075	1		HPC 3 days	0,676	0,951	1	
HPC 7 days	-0,229	0,022	0,723	1	HPC 7 days	0,684	0,951	0,998	1

Online results for **TA do not show clear correlation with reference laboratory methods** for global microbiological content such as HPC or ATP. However, collection and transportation of samples to laboratory can be confounding factors.

RESULTS AND DISCUSSION (1)

The whole TA dataset allowed to draw an **overview of microbial removal and regrowth** for the main DWTP of Barcelona, as it can be seen in Figure 3:

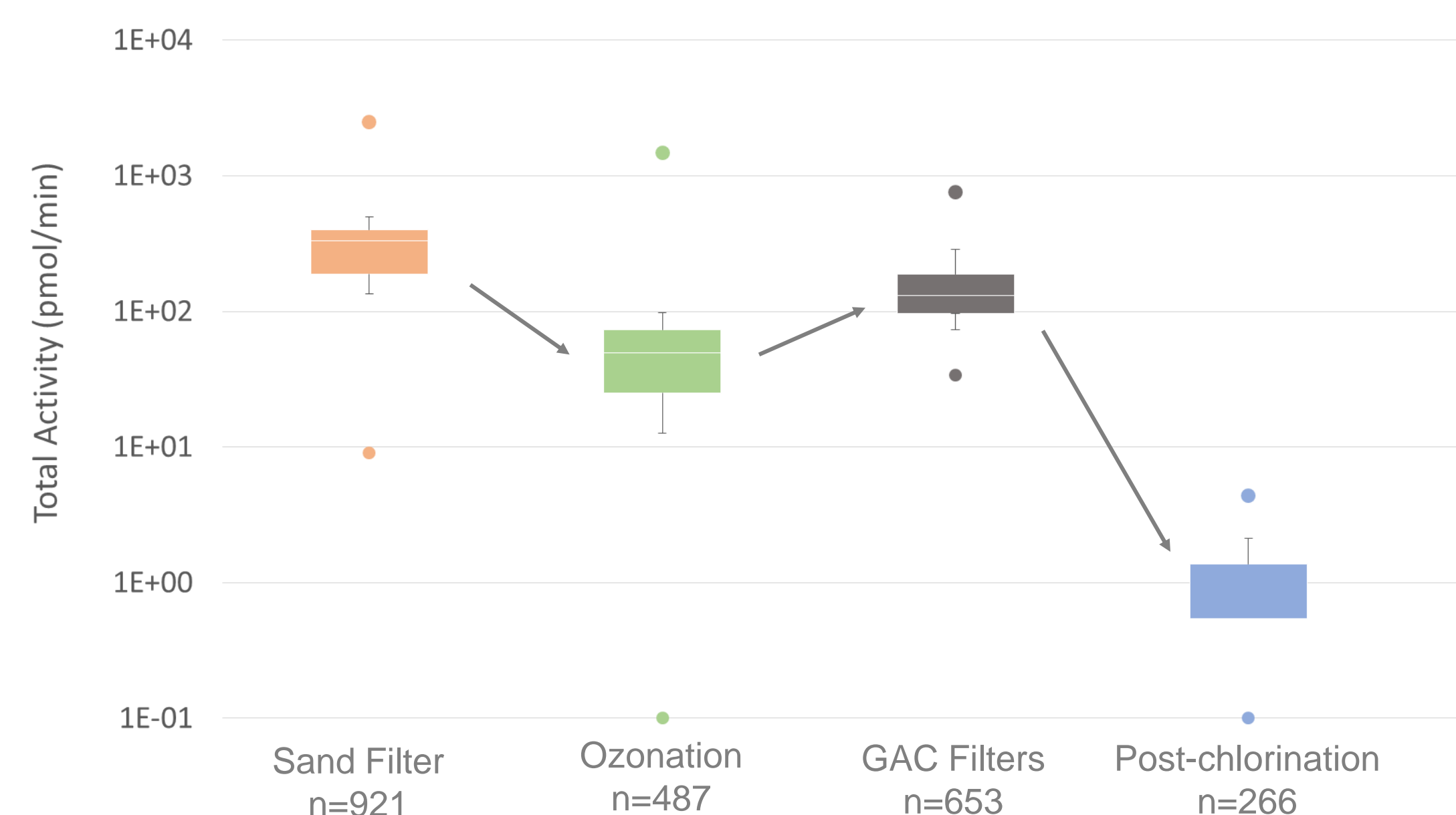


Figure 3 – Log removal boxplot based on Total Activity online values

CONCLUSIONS

- **BACTcontrol** is a robust and autonomous tool for **bacterial monitoring** in DWTP processes that can contribute to ISO 22000 implementation. Some applications are:
 - Assessment of **disinfection processes effectiveness**, as it refers to living cells.
 - Evaluation and control of **bacterial growth in filtration beds**.
 - **Early detection of microbiological events**, as it can be installed in pretreatment steps
- The response of the online system is totally **dependent on monitoring site**. Therefore, an in situ evaluation should be performed for each kind of matrix.
- Online results for TA do not show a clear correlation with standard laboratory methods for global microbiological content such as HPC or ATP. **Comparison with operational online parameters** is best recommended.

References: [1] ISO 6222:1999 Water quality - enumeration of culturable micro-organisms. Colony count by inoculation in a nutrient agar culture medium.

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