fluidion fluidion.com/en

Accurate rapid in-situ measurement of the microbiological impact of pollution sources

Dan Angelescu, Andreas Hausot, Joyce Wong, Vaizanne Huynh

Fluidion R&D division

Fluidion

fluidion *fluidion.com/en*

- A small company with an international footprint
- Specialized in novel water quality sensor and their use in complex studies
- Unique in-situ instruments:
  microbiology (*E.coli*), nutrients, oceanography
- Installations all over the world:
- USA, France, Germany, UK, Belgium,
  Italy, Portugal, Greece, Romania, S.Africa
- ETV-certified sampling technology
  (VN20180030) ETV
- Water quality aquatic drones

Paris Los Angeles

Context

Goal: quantify the in-situ impact of microbiological pollution and mitigation actions

- Models can be over-simplified and often lack adequate input data
- Pollution may be generated in random patterns, with many confounding variables
- Traditional point-sampling methods not representative
- Bacterial measurement methods inadequate for long-term in-situ monitoring

Case studies:

A. **Impact of untreated boat sewage on a receiving water body (Marne river, France)**
B. **3-year continuos monitoring of the Seine river (Paris, France)**
C. **Measuring efficiency of mitigation actions: pump-out (Lake Chelan, WA, USA)**
D. **Impact of sewage discharges in small rivers and streams (Tijuana river, CA, USA)**

fluidion fluidion.com/en

Instrumentation used

1. **FLUIDION® DRONE** for water quality, equipped with RS-14V ETV-certified sampler
2. **FLUIDION® ALERT LAB** portable *E.coli* analyzer
3. **FLUIDION® ALERT SYSTEM** in-situ *E.coli* analyzer
4. Aerial drone with camera
5. Fluorescence lamp and filtered camera for time-lapse fluorometry

1

2

3

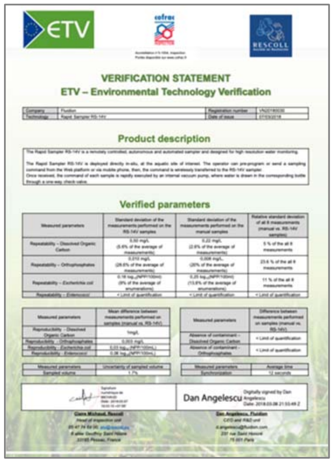
4

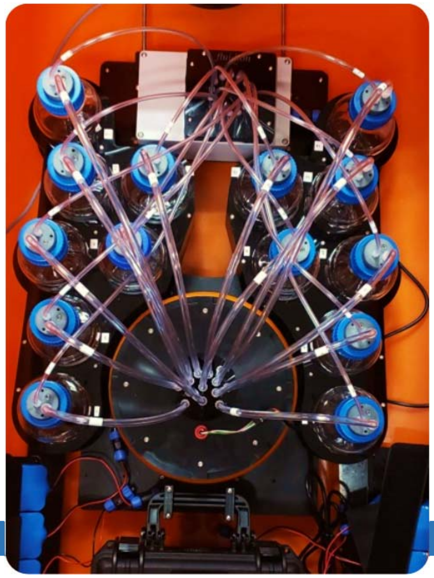
5

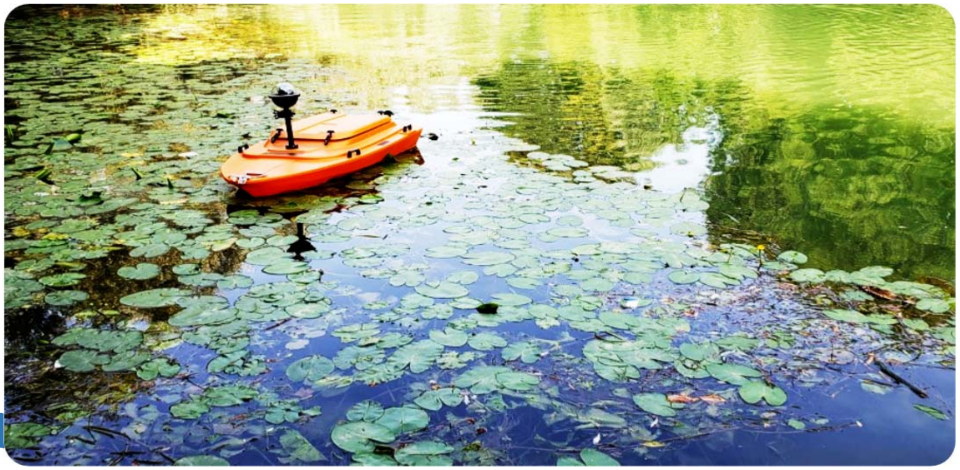
In-situ sampling

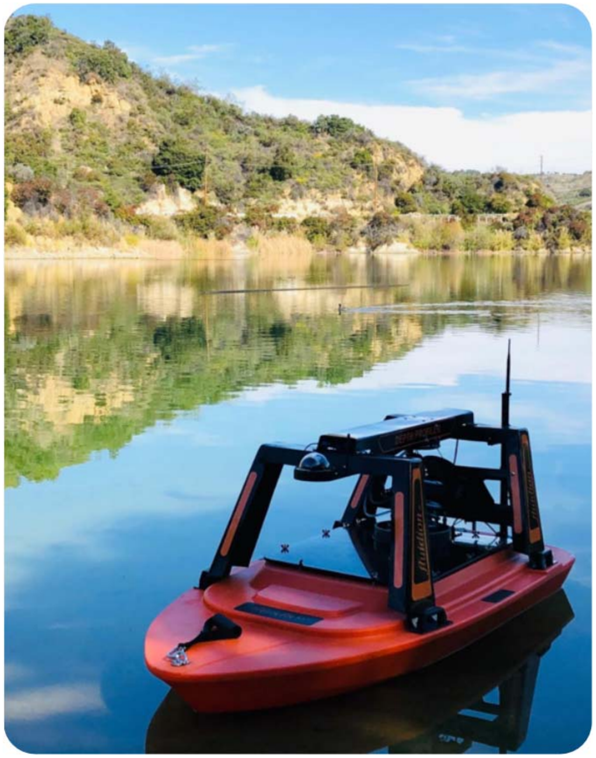
FLUIDION® DRONE Technology

RS-14V certified ETV sampler, 14 bottles X 500mL
Optional: multi-parameter YSI EXO2 sonde
Optional: 3m vertical profiler
Optional: nutrient and micropollutant sensors


VERIFICATION STATEMENT
ETV – Environmental Technology Verification
Product description
Verified parameters
Dan Angelescu







FLUIDION® ALERT Technology

Optimized liquid bioreagent (growth medium and indicator)

- Rapid culture-based method
- Enzymatic reaction with fluorogenic substrate
- Time-resolved optical detection (absorbance and fluorescence)

Bioreagent			
ONPG	→ **β-galactosidase**	**ONP** *Color*	*Presence of generic coliforms*
MUG	→ **β-glucuronidase**	**MUF** *Fluorescence*	*Presence of E.coli*

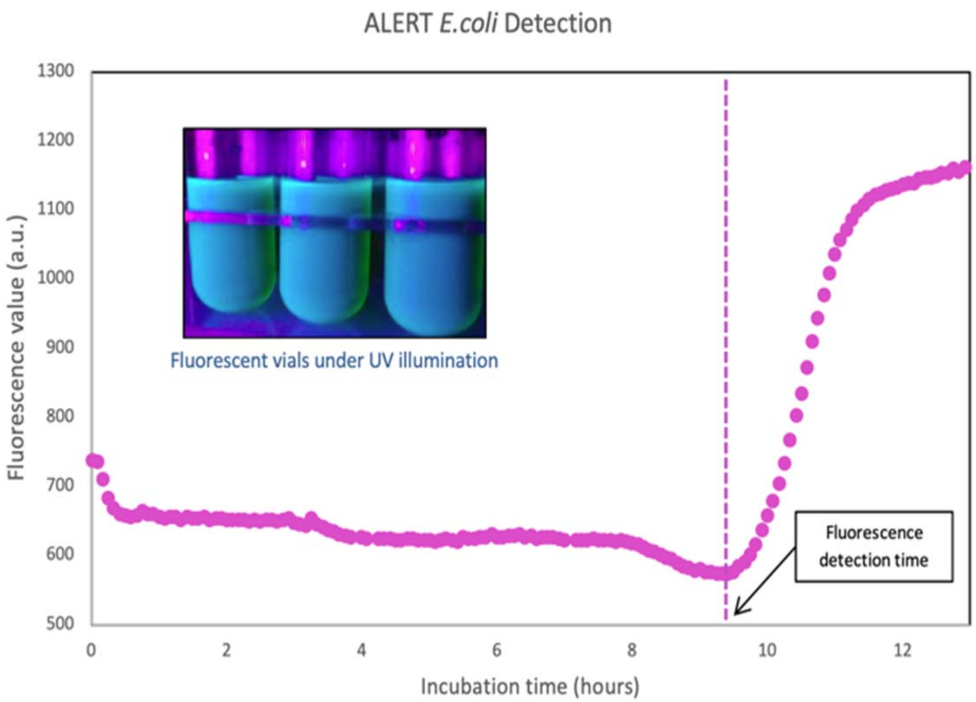
Bioreagent

ONPG: ortho-nitrophenyl-β-galactoside
MUG: 4-methylumbelliferyl-beta-D-glucuronide

ONP: ortho-nitrophenol
MUF: 4-methylumbelliferyl

FLUIDION® ALERT Technology

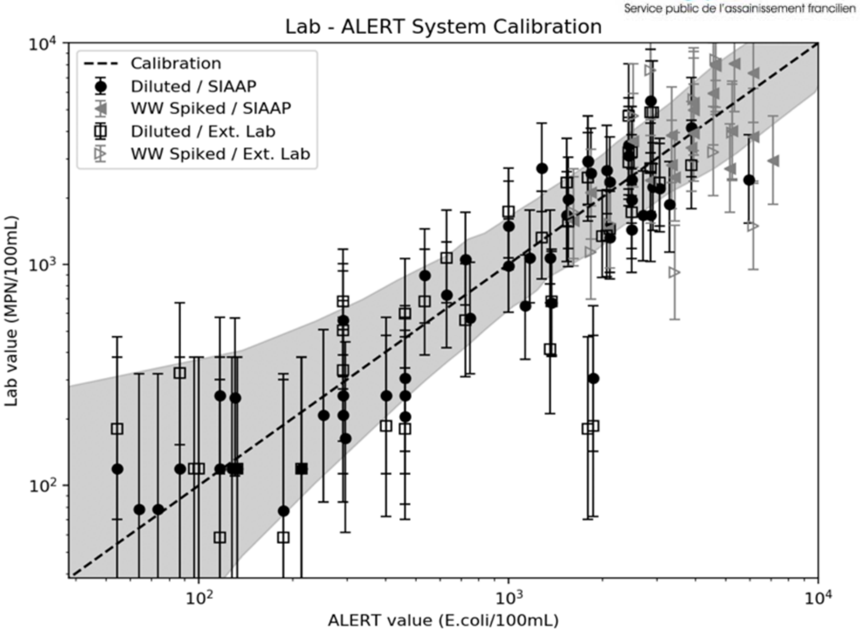
fluidion.com/en

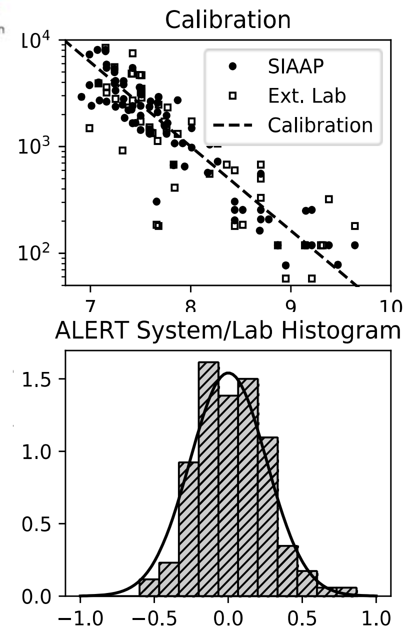


E.coli measurements in surface waters

fluidion fluidion.com/en

FLUIDION® ALERT Technology





Surface water calibration (Seine / Marne)


Journal of Applied Microbiology

Autonomous system for rapid field quantification of *E. coli* in surface waters

Running Head: Rapid autonomous system for E. coli quantification

Dan E. Angelescu[a], Vaizanne Huynh[a], Andreas Hausot[a], Gizem Yalkin[a], Victor Plet[a], Jean-Marie Mouchel[b], Sabrina Guérin-Rechdaoui[c], Sam Azimi[c], Vincent Rocher[c]

[a]Fluidion SAS, R&D Division, 231 Rue St. Honoré, 75001 Paris, France
[b] Sorbonne Université, CNRS, EPHE, UMR 7619 Metis, F-75005, Paris, France
[c]SIAAP, Direction Innovation Environnement, 82 Avenue Kléber, 92700 Colombes, France

Abstract

Aims: The purpose of this work is to present and evaluate the performance of a novel Automatic Lab-in-vial *E. coli* Remote Tracking (ALERT) technology based on an automated real-time defined substrate approach, and implemented in both portable and in-situ instruments.

Methods and Results: We present the fresh-water calibration procedure, and assess performance using side-by-side comparison with most-probable-number (MPN) approaches in terms of accuracy, reproducibility and capability to correctly generate early-warning alerts. Long-term data from an operational in-situ deployment at a potential bathing site is presented as well.

Conclusions: ALERT technology is shown to be an accurate and rapid bacterial quantification technology, capable of autonomous in-situ measurements with metrological capabilities comparable to those of an approved laboratory using MPN microplate techniques.

Significance and Impact of the Study: Rapid quantification of bacterial pollution is a requirement in water quality applications ranging from recreational water use, agriculture and aquaculture to drinking and wastewater treatment. The method and instruments presented in this work should enable fast and accurate bacterial concentration measurements to be performed in a portable or in-situ manner, thus simplifying operational logistics, reducing time-to-result delays, and eliminating sample transportation constraints associated with traditional techniques.

Keywords: Water quality; E.coli (all potentially pathogenic types); Environmental/recreational water; Rapid quantification; Surface waters; Wastewater; Rapid test

Introduction

Surface water quality (in lakes, rivers, and coastal areas) has a direct impact on the safety of recreational water users, and on ensuring safe supply for drinking, aquaculture and agriculture use. Microbiological pollution with human and animal waste pathogens can have a variety of sources. In urban areas, bacteria can enter waterways through effluent from wastewater plants, amplified during heavy rain episodes by sewer and sanitary overflow phenomena (McLellan et al. 2007), and in specific cases by boat sewage. In rural settings, pollution is generally associated with agricultural run-off (e.g. from livestock operations) or natural presence of birds and other warm-blooded animals. Exposure to fecal pathogens via contaminated water is a major health risk, causing a wide variety of illnesses and infections, with potentially fatal consequences in vulnerable populations with weaker immune systems, such as children and the elderly. Microbiological pollution also has a major economic impact. In Los Angeles and Orange Counties alone, 600,000 to 1.5 million gastrointestinal illness cases are caused by contamination of recreational water annually, with healthcare costs in excess of $21 million (Given et al. 2006). Additionally, beach access closures due to water quality issues impact local tourist-based economies and property prices.

The use of natural waters for recreational activities requires regular quality control checks to ensure public safety (European Council 2006; U.S. EPA 2012). The concentration of *Escherichia coli* (*E. coli*) bacteria shows direct correlation with gastrointestinal illness rates associated with recreational use and is generally accepted as a

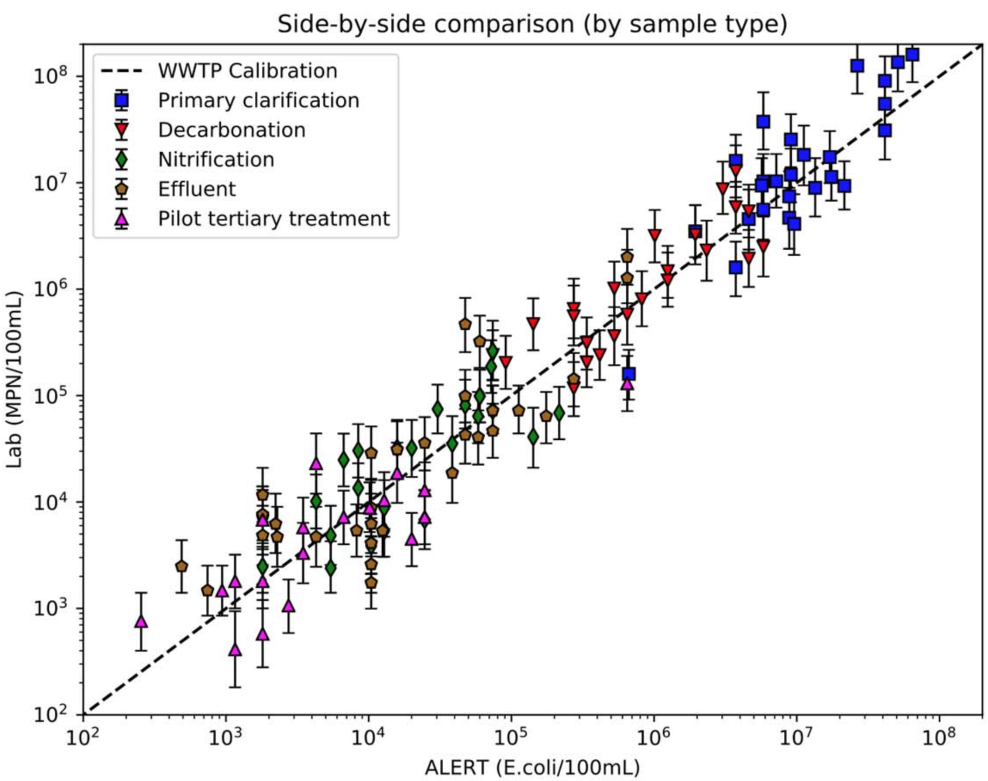
Angelescu, D. E. et al. (2018). Autonomous system for rapid field quantification of Escherichia coli in surface waters. *Journal of Applied Microbiology*, *126*, 332–343.

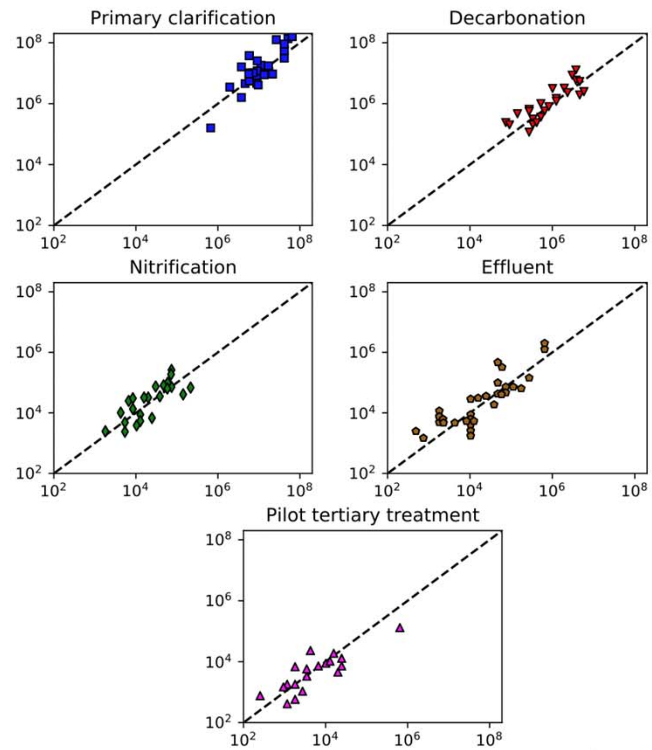
E.coli measurements in wastewater (raw and treated)

fluidion

fluidion.com/en

FLUIDION® ALERT Technology





Soon to appear in:

IWA the international water association

SIAAP Service public de l'assainissement francilien

Houseboats, barges and packetboats

fluidion

fluidion.com/en

Early Days of Rapid Transit / Edward Lamson Henry

https://harborcottagehouseboats.com/galleries/

https://depositphotos.com/123024826/stock-photo-amsterdam-canal-singel-with-dutch.html

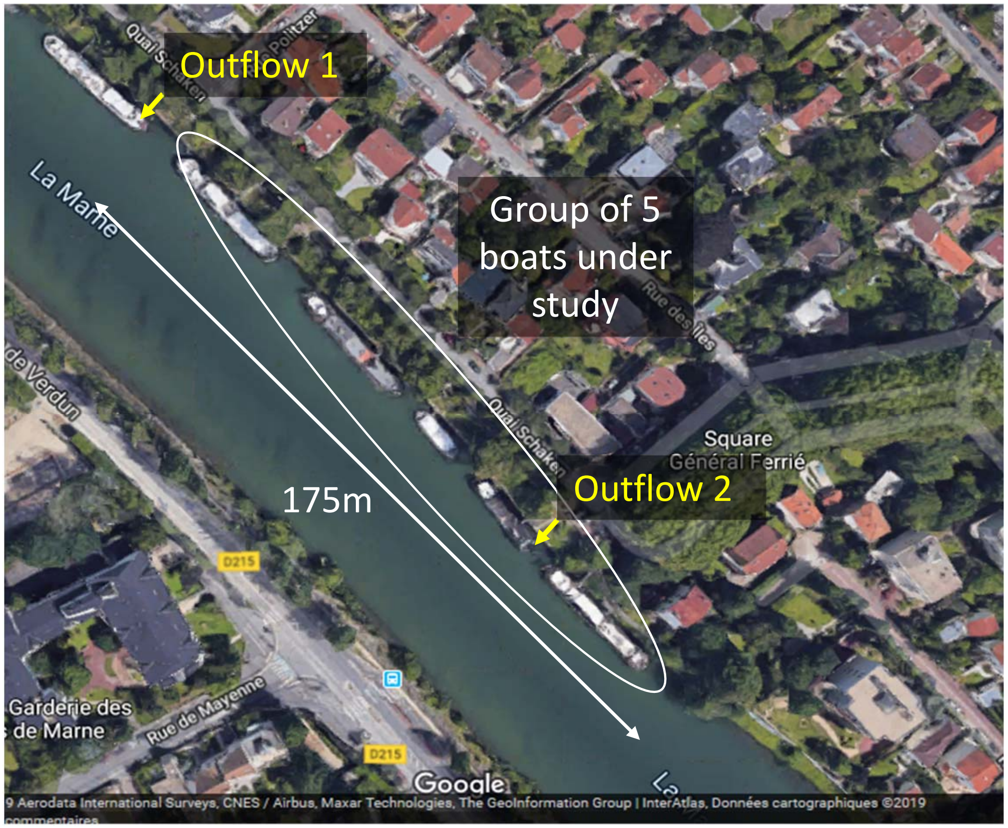
https://commons.wikimedia.org/wiki/File:France,_Paris,_des_p%C3%A9niches_sur_la_Seine_entre_le_Pont_des_Arts_et_le_Pont-Neuf.jpg

PARIS 2024
une célébration d'une vie

Preparing for the 2024 summer Olympic games: A major river bacterial reduction action throughout Paris region

Setup and methodology

fluidion fluidion.com/en



Three experimental stages:

1. High-frequency impact measurements during synchronized pollution (in-situ dispersion study)

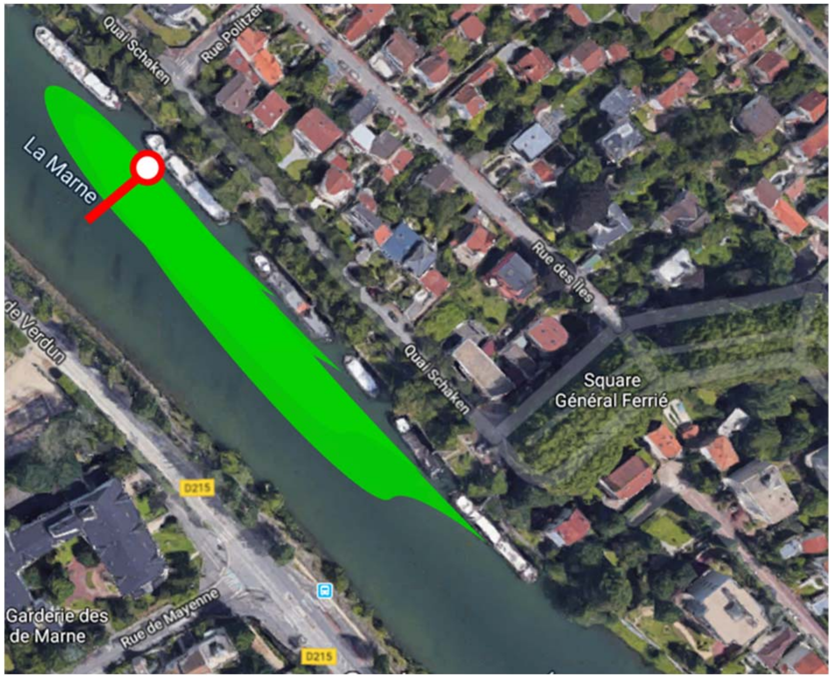
1. Greywater measurements by source of water (shower, laundry, dishwasher) and by boat

2. Long-term in-situ *E.coli* time-series and differential microbiology between upstream and downstream locations

In-situ dispersion study

Objectives :
1. Measure pollution travel time
2. Identify extent of lateral pollution
3. Measure downstream dilution factors
4. Measure downstream pollution duration

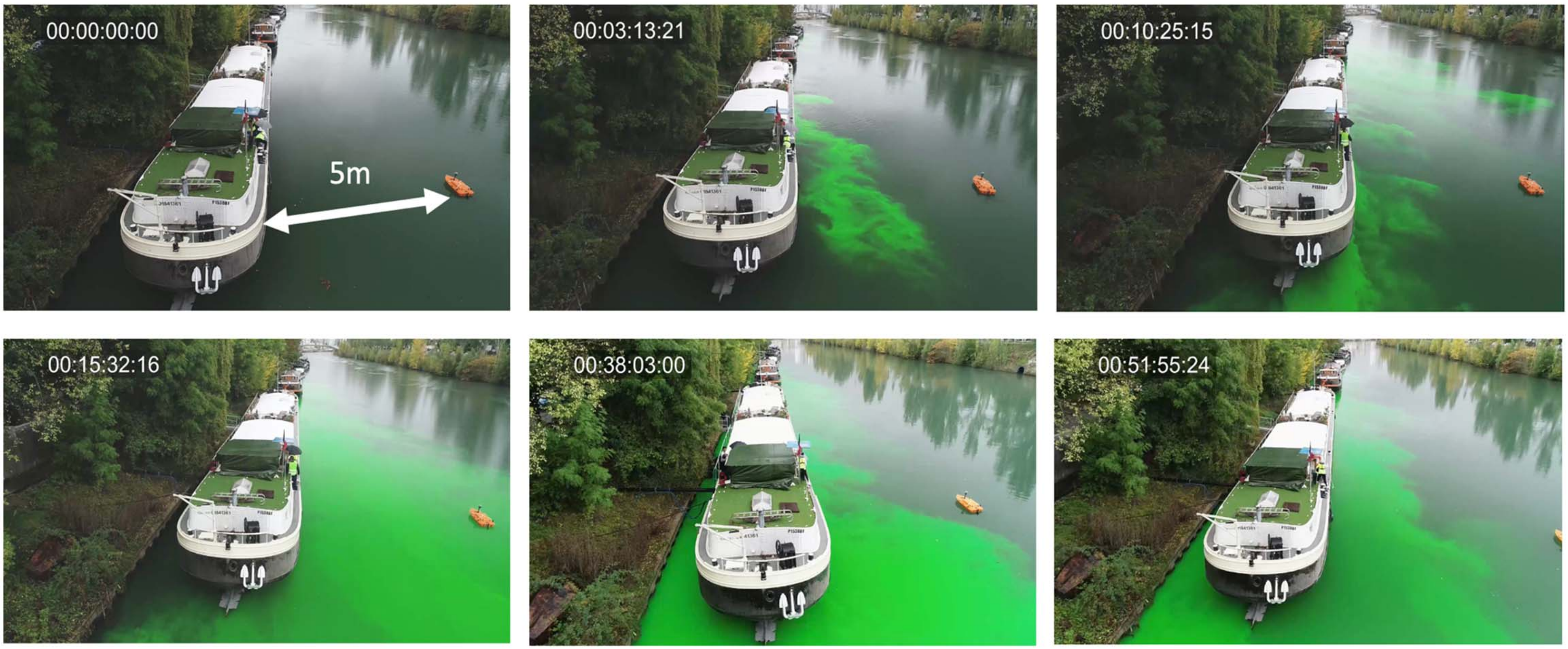
Techniques :
1. Simultaneous flushing
2. Time-lapse fluorescein tracing
3. 3-camera video recording
4. Downstream sampling (manual/drone)
5. Fluorescence measurements (comparator)
6. *E.coli* measurements



Time sequence of synchronized pollution

fluidion

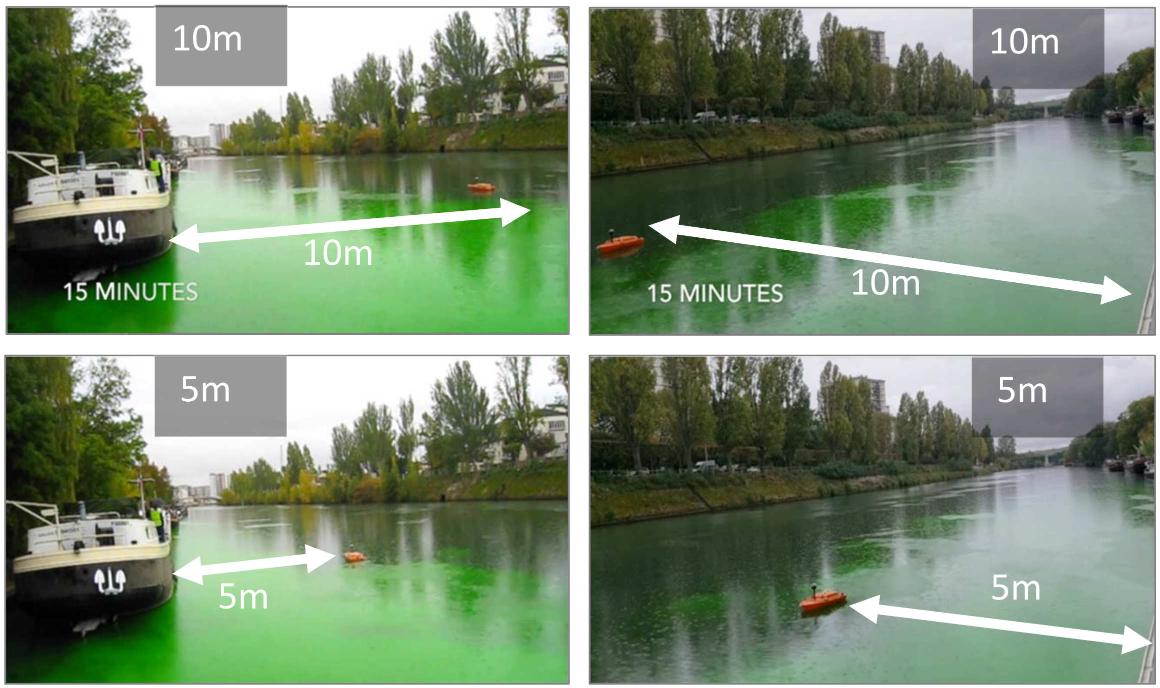
fluidion.com/en



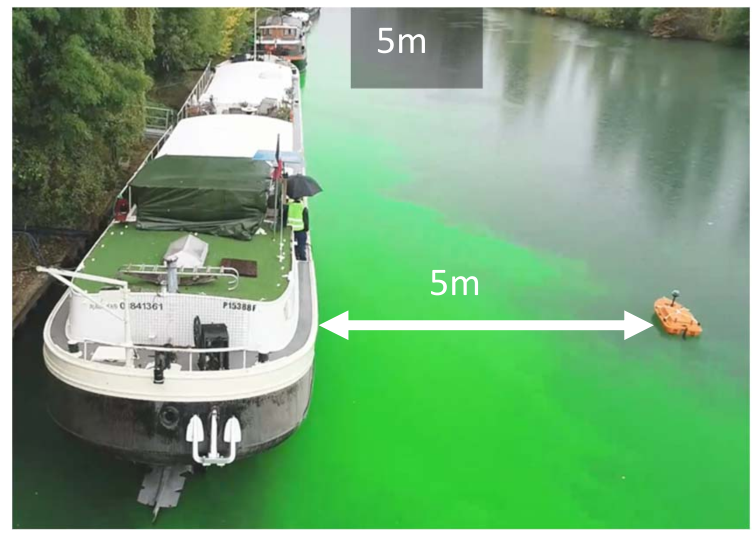
Lateral extent of downstream pollution

Maximum lateral impact: at 15’ (fixed camera and drone images)

Upstream Downstream



Lateral extent of pollution
11m maximum, observed at 15’

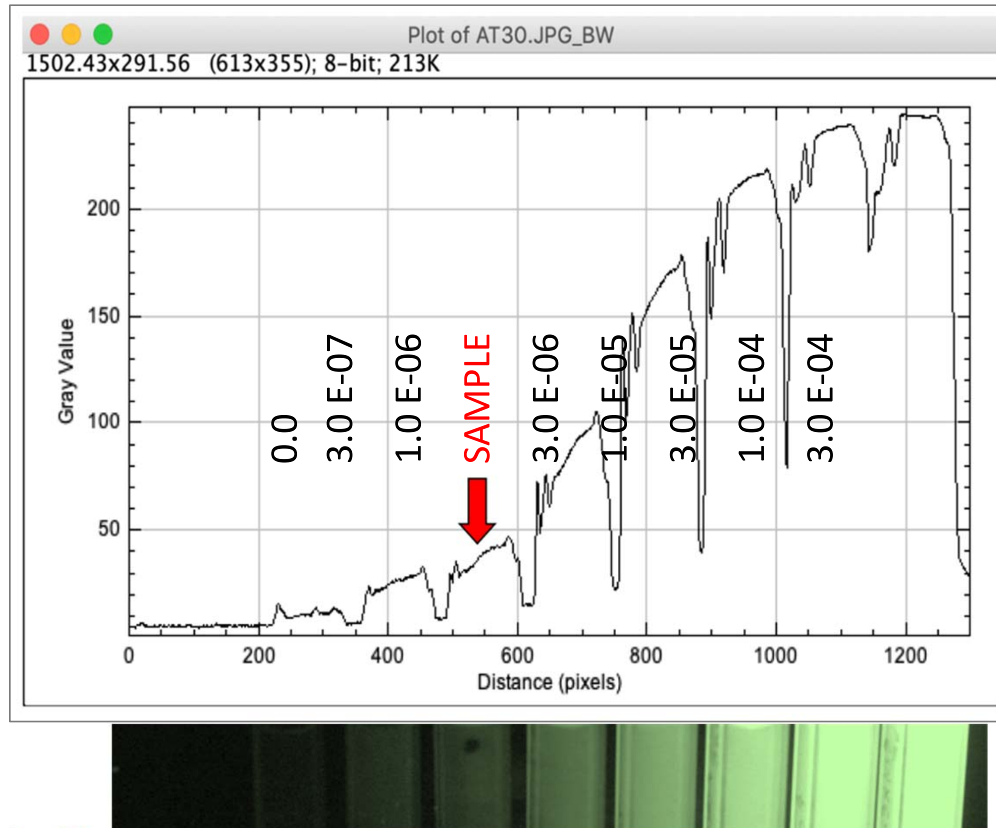


Dilution factor determination

Real river matrix (Marne) fluorescence comparator

Fluorescein solution 300g/L (Fluotechnik)

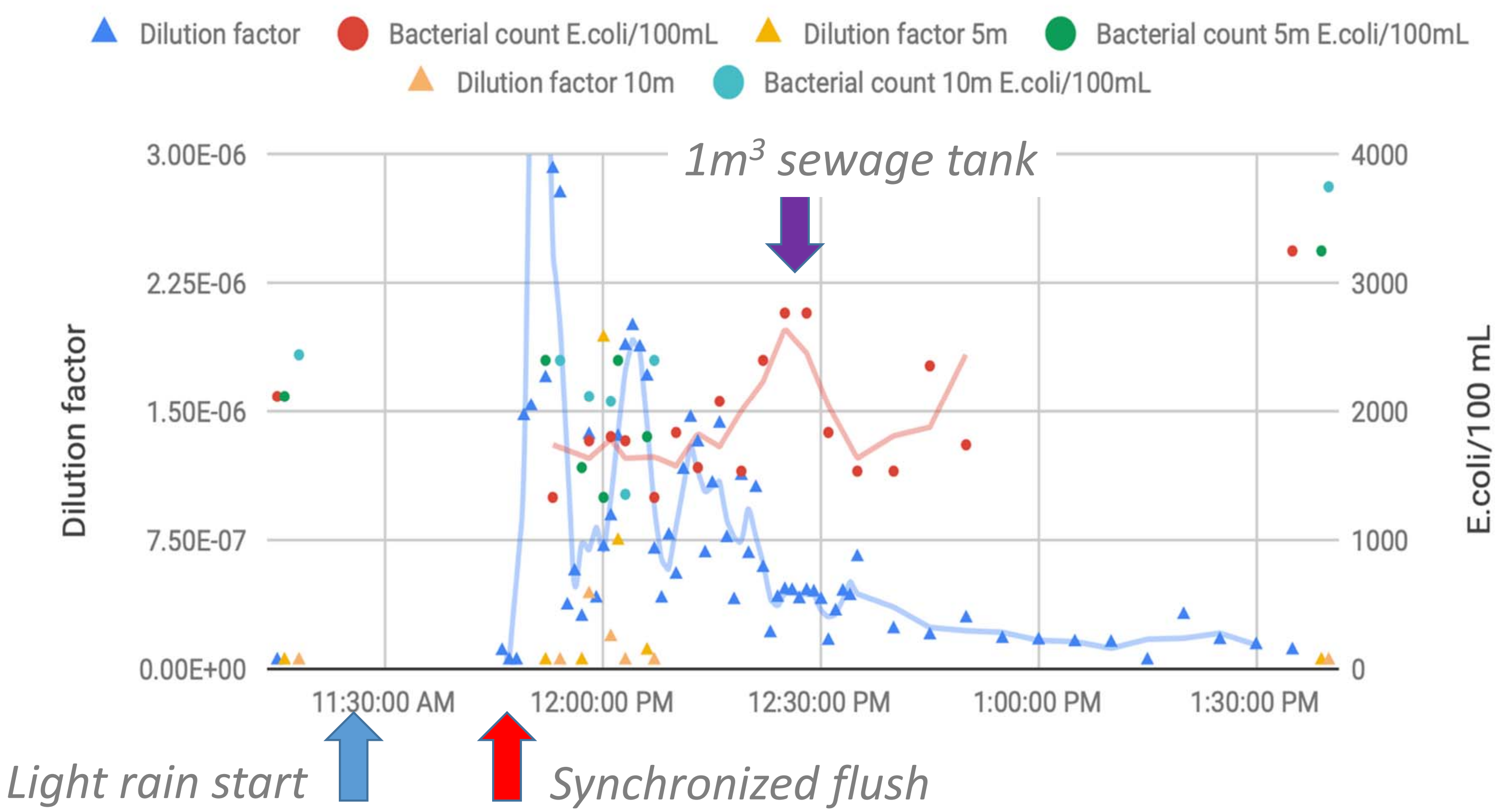
Linear interpolation between closest standards
Standard range: 0.0 – 3.0E-04
Reliable quantification range: 1.0E-07 - 1.0E-04
Quantification error: larger of 10% or 1.0E-07



In-situ dispersion results

fluidion

fluidion.com/en



sepia

ADHF-F

Fédération des Associations de Défense de l'Habitat Fluvial

Gray water and raw sewage measurements

Showers: High variability, between 0 and $5{,}0\times10^5$ E.coli / 100mL
Dishwasher : High variability, between 0 and $2{,}5\times10^4$ E.coli / 100mL
Laundry: between 0 and $1{,}9\times10^3$ E.coli / 100mL
$1m^3$ sewage tank: 7,5E+05 – 1,0E+06 E.coli / 100mL

Consistency check for $1m^3$ sewage tank:

2L Fluoresceine solution in 1000L : initial in-tank dilution 2,0E-03
Downstream measured dilution factor: between 3,0E-07 and 1,0E-06

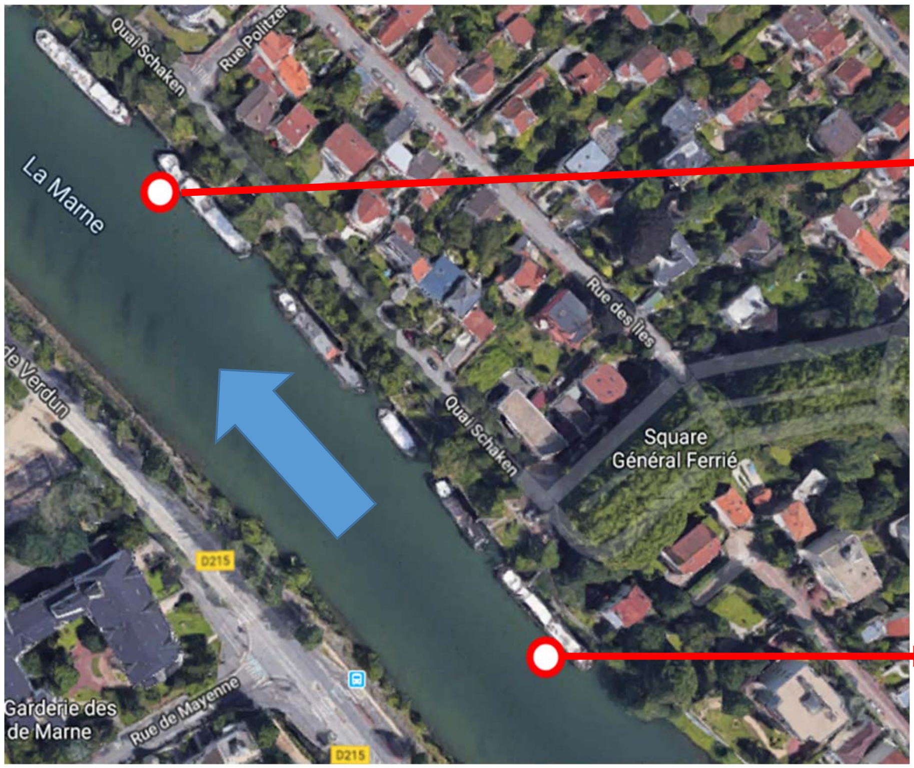
→ Actual sewage dilution factor: between 1,5E-04 and 5,0E-04

Downstream calculated E.coli contribution : 112 – 500 E.coli / 100mL
Downstream measured E.coli contribution : < 1000 E.coli / 100mL

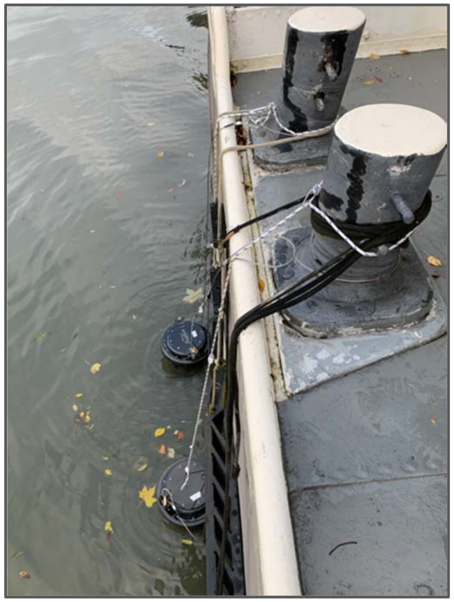
Good correlation between theory and measurement

Long-term installations

fluidion *fluidion.com/en*



Upstream installation

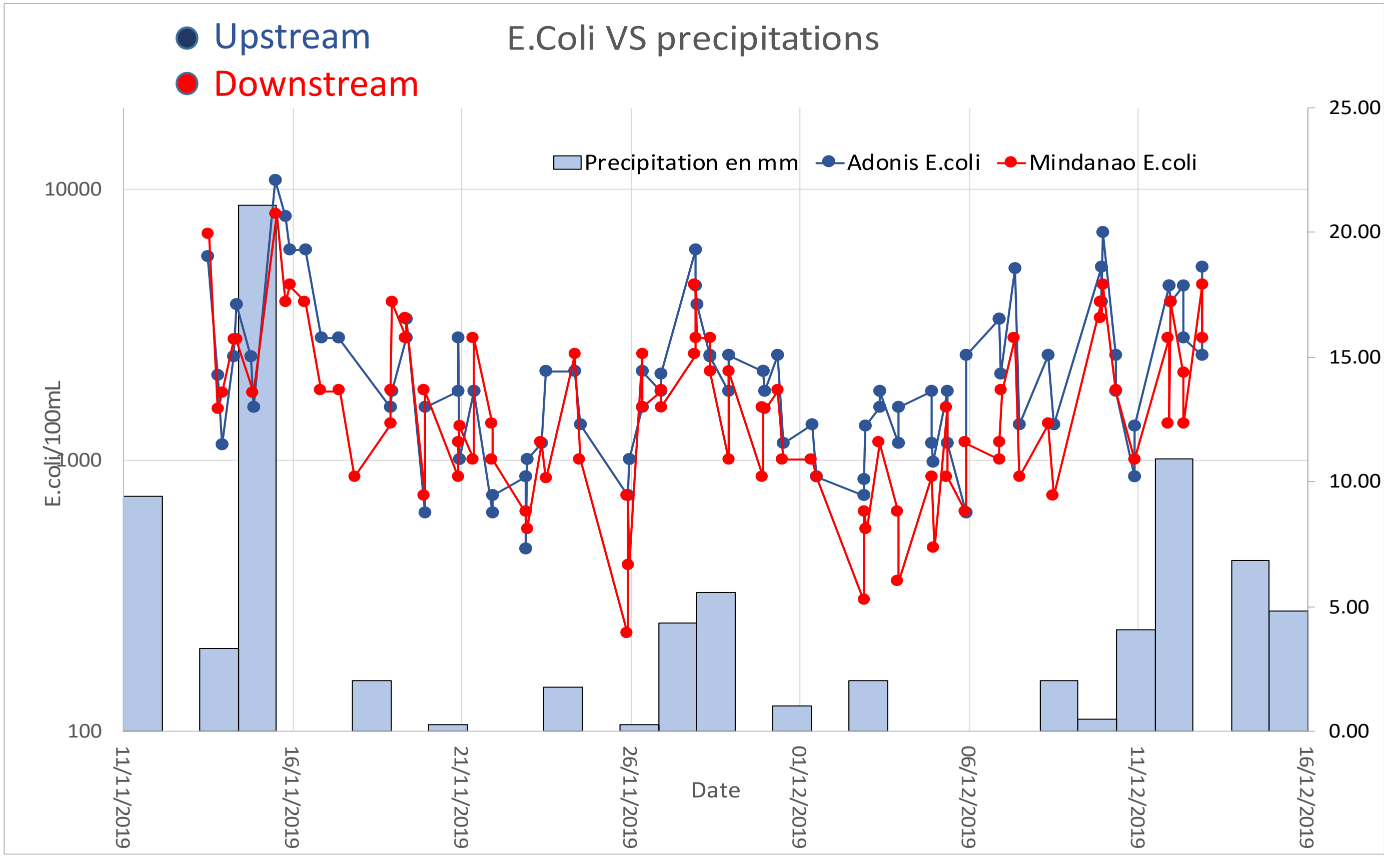


Downstream installation

In-situ *E.coli* long-term time-series (30 days, 3 measurements / day)

fluidion

fluidion.com/en



sepia

ADHF-F

Fédération des Associations de Défense de l'Habitat Fluvial

Some interesting conclusions

fluidion fluidion.com/en

Downstream measurements consistently higher than upstream (80% of the measurement), suggesting local source of contamination upstream

High variability of greywater bacterial content

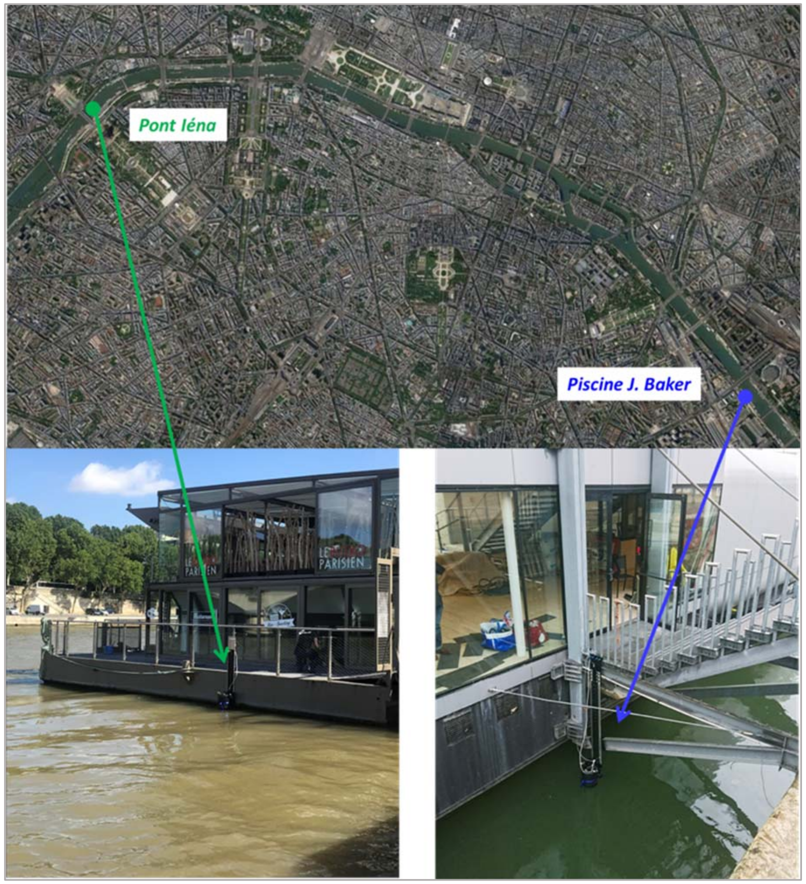
$10^{-3} – 10^{-4}$ dilution factors for homogenized wastewater: 150m downstream impact non-measurable for greywater at typical volumes used

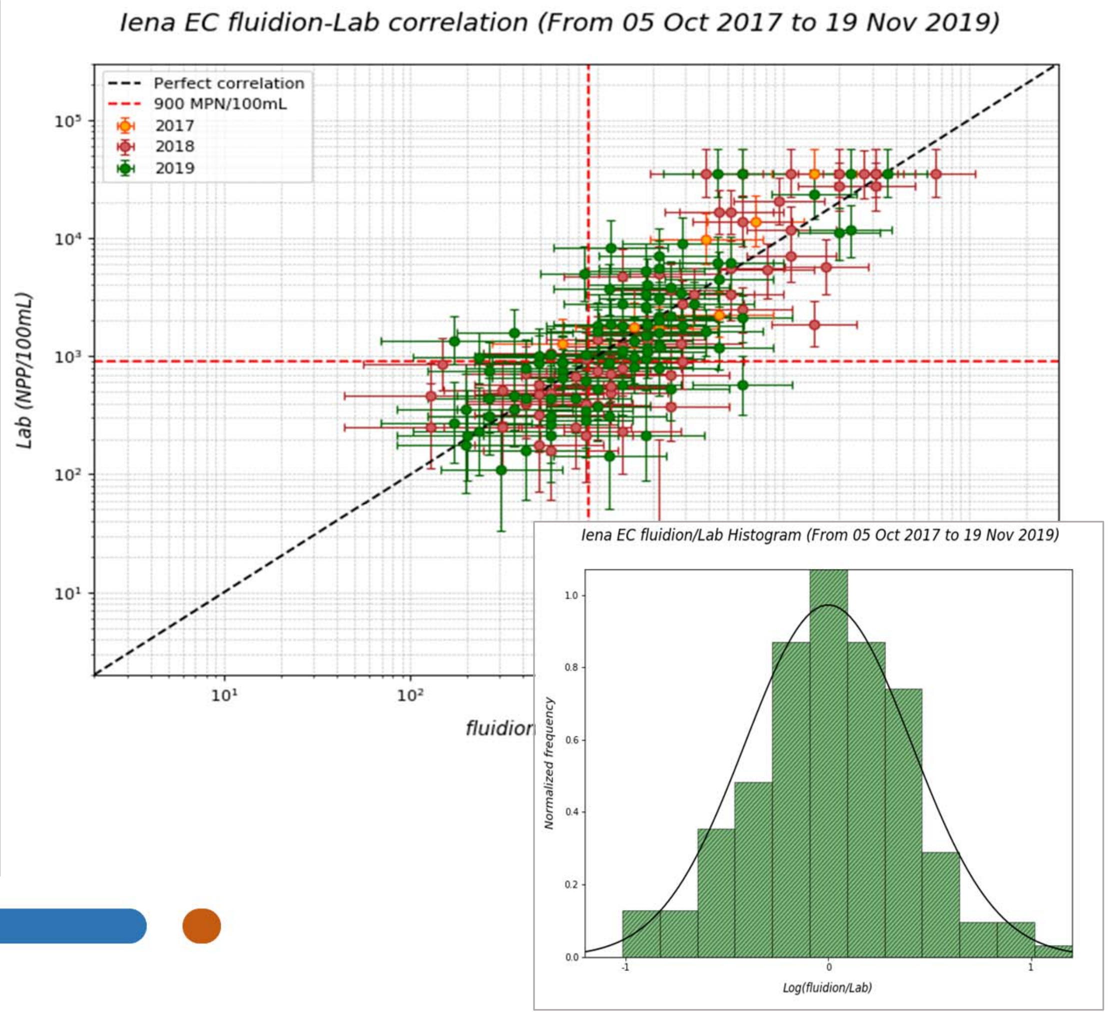
Effect of land-based outflows significantly higher than untreated boat sewage

Solid fecal matter can have large impact farther downstream: treatment and disinfection advised

Floating debris accumulation upstream due to local river flow configuration

Long-term river monitoring

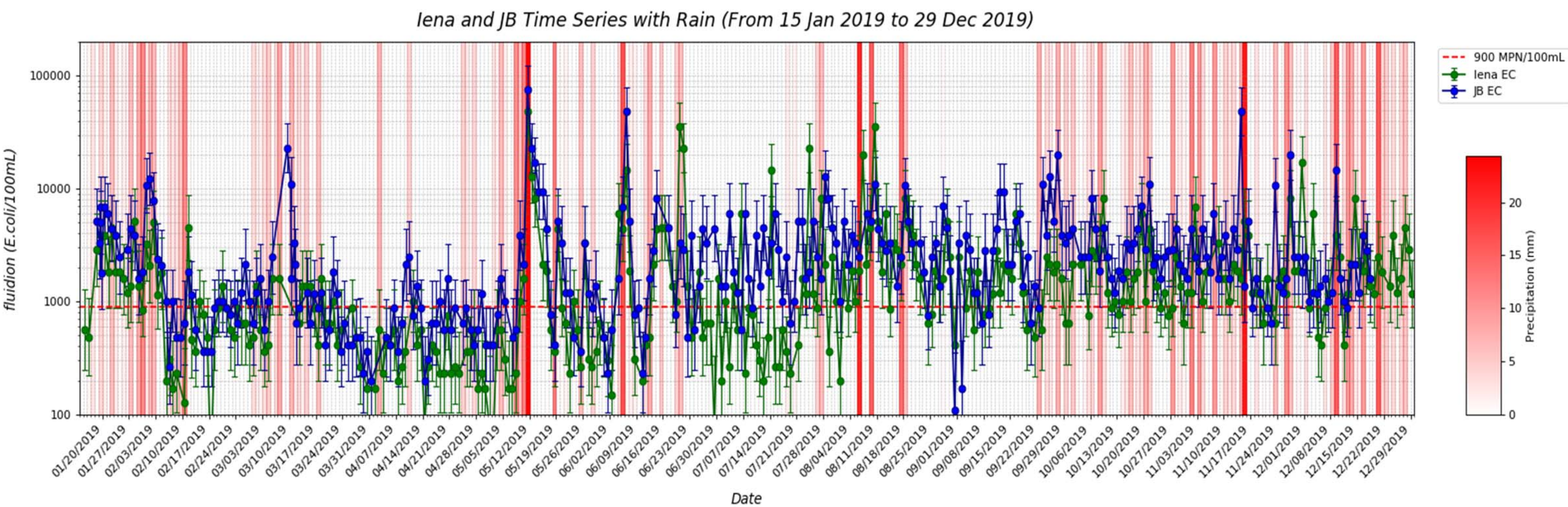




Stormwater / CSO monitoring
2019 Paris data

fluidion

fluidion.com/en



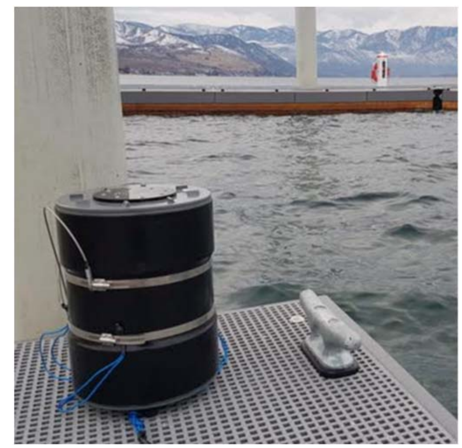
PARIS

Evaluating mitigation actions

Pump-out stations installed at Lake Chelan marinas
Protecting a sensitive and pristine environment
Using ALERT System to evaluate long-term effects
Outstanding results (majority of measurements below detection limit of 4 E.coli /100mL)

Sea Grant Washington

Lake Chelan Research Institute

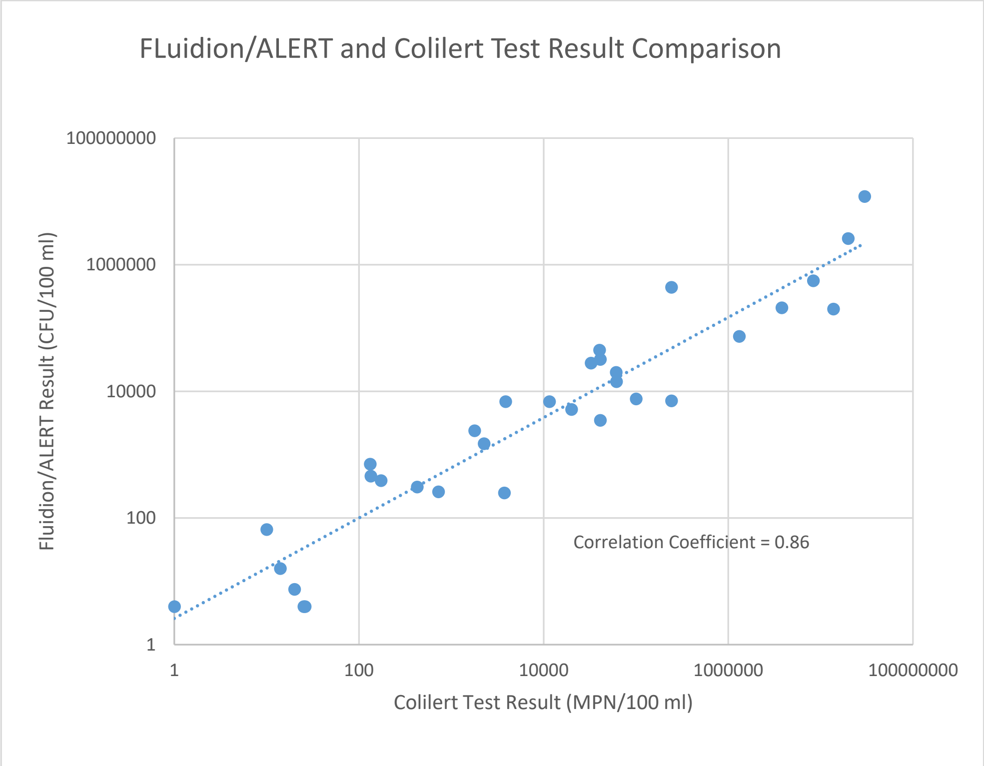


Evaluating impact of illegal sewage dumping

fluidion

fluidion.com/en

Measuring bacterial contamination in Tijuana river (2017, on-going)



CALIFORNIA Water Boards STATE WATER RESOURCES CONTROL BOARD REGIONAL WATER QUALITY CONTROL BOARDS

Excellent comparison with data from EPA-approved methods over 8 LOG units.

This study was instrumental in issuance of an investigative order by the California regional water quality control board (San Diego) for:
INVESTIGATION OF POLLUTION, CONTAMINATION, AND NUISANCE FROM TRANSBOUNDARY FLOWS IN THE TIJUANA RIVER VALLEY

CALIFORNIA WATER BOARDS San Diego - R9

Conclusions

- A novel methodology for in-situ monitoring of microbiological pollution (*E.coli*)
Identification and quantification of localized and diffuse pollution sources
- Robust impact measurement on the receiving water bodies
- Long-term time-series evaluation
- Robotic and automated technologies (drone sampling and visual monitoring, autonomous instruments)

❖ Impact studies in sensitive areas
❖ Bathing water active management
❖ Pollution source identification
❖ High-resolution environmental monitoring

Acknowledgements

The following organizations provided support and / or expertise that made this work possible:

CALIFORNIA WATER BOARDS San Diego - R9

Sea Grant Washington

LA DWP Los Angeles Department of Water & Power

sepia CONSEILS

Lake Chelan Research Institute

ADHF-F Fédération des Associations de Défense de l'Habitat Fluvial

eau seine NORMANDIE Agence de l'eau

PORTS de PARIS HAROPA

vnf Voies navigables de France

PARIS

SIAAP Service public de l'assainissement francilien

fluidion fluidion.com/en

Thank you !

For any questions or requests: contact@fluidion.com